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ABSTRACT

Two hundred nine Puerto Rican students in East Coast colleges, from mixed bilingual backgrounds, were administered four matched pairs of deductive reasoning tests in Spanish and English. Measures of reading comprehension in these two languages were also collected. Results indicated that performance on logical reasoning tests in each language can be significantly predicted by measures of reading comprehension skill in the language of the test and that the pattern of prediction is very similar across languages for any pair of reasoning tests. The relationship of a few selected background characteristics of subjects to reasoning test performance was found to be mediated through measures of reading comprehension skill in the language of reasoning tests. Discrepancy between level of performance on Spanish versus English reasoning tests was most apparent for subjects found to show the most discrepancy between reading comprehension skills in Spanish and English. Finally, substantial statistical evidence exists that solution of logical reasoning problems in Spanish and English may involve common thinking skills that are psychologically discriminable from reading comprehension skills. (Author/JB)

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FINAL REPORT

National Institute of Education

Grant # NIE-G-78-0135

LOGICAL REASONING SKILLS OF PUERTO RICAN BILINGUALS

Richard P. Duran
Educational Testing Service
Princeton, New Jersey

October 1979

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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Abstract

Previous research on the connections between bilingualism and thought has verified the intuitively appealing but nontrivial hypothesis that bilinguals are better at solving problems stated in a stronger language than in a weaker language. Relatively little research, however, has addressed the extent to which ability to solve verbally stated reasoning problems in one language or another is actually related to relevant linguistic processing skills in the respective language of problems. Thus we know very little about whether language abilities relevant to solving problems stated in a language show a similar pattern of relations to problem solving skill across two languages, and as a further issue we know very little about how such relationships subsume the influence of background factors, involving sociocultural, educational and linguistic experiences on ability to solve reasoning problems in either of two languages.

While previous studies of bilinguals and their problem solving skills have taught us much, there are very real questions about the applicability of previous findings to Puerto Rican bilinguals in U. S. schools since Puerto Ricans as a whole manifest mixed bilingual backgrounds, generally, with Spanish as a first conversational language but with many different patterns of exposure to both Spanish and English in literacy settings. Thus we know very little about how language abilities of Puerto Ricans influence their facility in working cognitive tasks written in either of two languages. As a further concomitant issue, we have no evidence on how sociocultural, schooling and language experiences among Puerto Ricans might be related to demonstrating skills in solving problems in either of two languages, independent of the role played by comprehension skill in the language of problems. Finally, we have little or no evidence to support the conclusion that Puerto Ricans (or any other ethnolinguistic group for that matter) manifest the same underlying reasoning skills in working similar verbal reasoning problems of related types across two languages.

The present study investigated these issues among 209 bilingual, male and female, Puerto Rican students enrolled primarily in four-year East Coast colleges. The students, averaging 22 years of age, who were sampled for study, came from mixed bilingual backgrounds with around one-half having received at least some schooling in Puerto Rico in Spanish with English taught as a second language. Most students were found to be dominant in reading English over Spanish. Students were administered four matched pairs of deductive reasoning tests in Spanish and English, and measures of reading comprehension skill in Spanish and English were also collected along with background information focusing on sociocultural, language, and schooling experiences of subjects on Puerto Rico and the U. S. Mainland.

Reading comprehension measures collected right during administration of logical reasoning tests in each language included average reading time per items on a test, number of items on a test where subjects were aware of mental translation into the other language, and number

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of words or sentences across items on a test which were not understood in context. In addition two matched Spanish and English general reading comprehension tests were administered separately and yielded measures reflecting skills in vocabulary recognition, reading speed and ability to recognize paraphrase in a language.

The results of the research show that performance on logical reasoning tests in each language can be significantly predicted by the aforementioned measures of reading comprehension skill in the language of tests and that the pattern of prediction is very similar across languages for any pair of reasoning tests. Other preliminary findings indicated that the relationship of a few selected background characteristics of subjects (such as years schooled or lived on Puerto Rico versus the U. S. Mainland, socioeconomic status of parents, and professional plans) to reasoning test performance in Spanish and English was entirely mediated through measures of reading comprehension skill in the language of reasoning tests. The sole exceptions to this regularity were the findings that increased exposure to English in high school and judgment of English as the best reading language had small but statistically significant facilitating effects on solving logical reasoning problems in Spanish beyond the facilitation provided for by reading comprehension skill in Spanish. Another result established that discrepency between level of performance on Spanish version versus English version reasoning tests was most apparent in the expected directions for subjects found to show the most discrepancy between reading comprehension skills in Spanish and English. A final result was that substantial statistical evidence exists that solution of logical reasoning problems in Spanish and English on all four pairs of reasoning tests used in the present study may very well involve common thinking skills i.e. rules for logical reasoning--which are psychologically discriminable from separate reading comprehension skills in each language required to understand the statement of logical reasoning problems. This finding is especially interesting since previous work on English-only versions of the reasoning tests used in the current study among U. S. English monolinguals has shown that the reasoning instruments tap a set of common thinking skills.

Caution needs to be exercised in generalizing the results of this study to other cognitive skills interacting with language ability for the population studied, and even to further deductive reasoning tasks that might be stated in a richer repertoire of Spanish and English familiar to the population studied. Caution also needs to be exercised in generalizing the results to other more representative segments of the adult Puerto Rican population. Overall, the results of the present study reinforce the educational importance of careful investigation of individual differences in the assessment of thinking skills of bilingual persons in relation to their language proficiencies and sociocultural background.

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CHAPTER I

INTRODUCTION

Despite the extensive history of research in the connections between bilingualism and thought, very little attention has focused on the assessment of bilingual's ability to solve very similar or identical high level problems stated in each of two languages. Over the years cumulative research on cognition and bilingualism has tended to emphasize the strong links that exist between problem solving skills in a language, proficiency in a language and cultural experience surrounding language use. Much of this research has been in response to the gross inadequacies in early research which was interpreted to show that monolinguals outperformed bilinguals on cognitive tasks and that bilinguals may in fact suffer cognitive handicaps as a result of having to learn and use more than one language system. In recent years research on bilingualism and cognition has tended to show that the findings of early studies were seriously confounded with socioeconomic and cultural factors which introduced unrecognized bias into the conduct and interpretation of research. Indeed, recent research has come to show that by carefully matching socioeconomic and educational background of monolingual and bilingual subjects, that bilinguals suffer no cognitive deficits as a consequence of their knowledge of two languages and that in fact balanced bilinguals of high proficiency in two languages might have enhanced cognitive abilities over monolinguals as a result of their facility with two language systems. Yet, by and large, research on bilingualism and cognition has tended to avoid research on within bilingual-group differences

that might account for how level of proficiency in each of two languages might be related to performance of cognitive tasks stated in one language or the other. Such research is sorely needed to improve our understanding of how individual differences in the language and thinking abilities of bilinguals interact and eventually on how we might maximize the learning and performance of bilinguals in monolingual and bilingual educational settings.

The purpose of the current research was to investigate how well bilingual Puerto Rican college students could solve logical reasoning problems stated in written form in either Spanish or English. The central focus of research was on the following question areas:

Area 1: To what extent is the ability to solve logical reasoning problems written in either Spanish or English related to reading comprehension ability in each language and are there factors in Puerto Rican's language background and schooling that need to be taken into consideration in formulating and answering such a question?

Area 2: What evidence exists that skill in solving logical reasoning problems in either Spanish or English represents a single unique skill distinct from reading comprehension ability in either language?

Area 3: How does level of performance on Spanish versus English logical reasoning tests change in relation to Puerto Ricans' reading comprehension profile in both Spanish and English?

The particular research approach taken in the current study is best understood in the context of a review of past research in the area of bilingualism and cognition. Much of this research has centered on contrasting monolingual and bilingual performance on cognitive tasks or has investigated how bilinguals' performance on tasks stated in language is related to whether a language is a first or second language. The review of past research is followed by a discussion of its relevance to the present study.

Past Research in Bilingualism and Cognition

An examination of recent major reviews of research on bilingualism and cognitive abilities by Padilla (1979) and Zirkel (1975) with regard to U.S. Hispanics and by Lambert (1977), Segalowitz (1977), and Cummins (1976) with regard to international populations reveals that very little attention has focused on how the performance of specific cognitive abilities tasks, such as logical or deductive reasoning, is explicitly influenced by the linguistic processing demands of tasks, as well as by the language proficiency skills and language background of bilinguals.

Most studies of U.S. Hispanic mental abilities have involved tests of general intelligence and have tended to show that bilingual Hispanics perform better on tests in their first language-Spanish (Mahakian, 1938; Sanchez, 1934; Mitchel, 1937) or on (nonverbal) performance tests of intelligence (Christiansen & Livermore, 1970; Darcy, 1952) as compared to their performance on English version intelligence tests. While many researchers have pointed out problems in equating English language cognitive tests with their literal Spanish counterparts (De Avila &

Havassy, 1974; Laosa, 1977; Padilla 1979; Sanchez, 1934) no systematic studies of mental processing difficulties induced by inappropriateness of translacion have been done apart from taking note of the fact that difficulties are present. A number of studies on Hispanic mental abilities have also shown that performance on tests is influenced by a number of subject background and methodological variables including sex, educational environment, socioeconomic status, familial structure, ethnicity of tester, etc. (Zirkel, 1975).

In passing it should be mentioned that almost all of the major studies on Puerto Rican cognitive abilities and bilingualism have focused on assessment of general intelligence (e.g., Anastasi & Cordova, 1953; Anastasi & DeJesus, 1953; Darcy, 1952; Green, 1964, 1969; Hertiz & Birch, 1971; Thomas, et al., 1971), rather than on more specific congitive abilities. A very well known study by Lesser, Fifer and Clark (1965) did investigate more specific types of cognitive abilities, such as verbal ability, reasoning, number facility, and space conceptualization among Chinese, Jewish, Negro, and Puerto Rican 6- and 7-year-old children but did not investigate bilingualism. The results of the study showed among other things that social class (middle or low) affected performance in the obvious direction regardless of ethnicity for tests and that Puerto Ricans consistently performed most poorly or next to most poorly on all tests in relation to other ethnic groups.

Turning to research on the connections between bilingualism and cognitive abilities not restricted to Hispanics, a moderately large body of research has investigated how performance of specific kinds of cognitive tasks is constrained by the language of tasks and the relative proficiency of bilinguals in two languages. An excellent and extensive

summary of previous research showing that bilinguals perform poorer on low level perceptual, reading, and decision making tasks involving use of a nondominant language is found in Dornic (1977). A general conclusion to be drawn from Dornic's review relevant to the current project is that reading speed is a critical determinant of success in low level problem solving in a nondominant language. The remainder of discussion in this review will focus on studies involving bilingual's ability to solve more complex reasoning problems in two languages.

Macnamara (1967) reported that in 22 studies of arithmetic reasoning, bilinguals were found inferior to monolinguals in correctly solving verbal arithmetic problems when the langauge of problems was the language of instruction. However, no such differences in problem solving ability occurred for mechanical arithmetic problems involving no verbal materials. Macnamara (1967, page 122) states that the observed pattern of these results is "... probably due to the fact that in mechanical math the student is simply required to carry out an arithmetical operation indicated by an arithmetic symbol, whereas in tests of problem (i.e., verbal) arithmetic he is required to read and interpret prose passages."

A study by the International Institute of Teachers College, Columbia University (1926), on the verbal arithmetic probvlem-solving ability of Puerto Rican bilinguals educated on the island of Puerto Rico found that 12th grade Puerto Ricans performed more poorly than monolingual U.S. 12th graders despite the fact that the Puerto Rican subjects had received arithmetic instruction in English since the fifth grade. According to Macnamara (1967) this result suggested that problem-solving skill in a

second language is constrained by linguistic proficiency difficulties that extend beyond the initial stages of learning a new subject matter in a second language.

In order to pinpoint the locus of some linguistic difficulties in solving problems in a second language, Macnamara and Kellaghen (1968) presented three verbal arithmetic problems in both Irish and English to two groups of sixth standard primary school males whose first language was English. One group of subjects of 20 males had been instructed solely in Irish, while the other group of 20 males had been instructed solely in English. For both groups of subjects oral reading time of Irish problems was significantly longer than oral reading time for English problems, despite the fact that the verbal problems in each language had been equated for number of words. Other studies which have supported the finding that reading time is slower in a second language than in a stronger first language are reported by Lambert, Havelka, and Gardner (1959) and by Kolers (1966). While these studies focus on oral reading time, a study by Lambert (1955) measuring simple response times to instructions delivered in two languages showed that bilinguals were slower to respond to instructions in the second language and thus support the hypothesis that comprehension as well as production is slower in a second language.

As part of their research, Macnamara and Kellaghen (1968) report another study investigating problem-solving ability in two languages that on this occasion focused on whether understanding the subparts of a verbal problem equally well in two languages would be followed by an equivalent success rate in solving a problem completely in two languages. Their results showed that understanding the meaning of individual sentences in a problem (as measured by an ability to answer a question about their

meaning) does not lead to an equal success rate for solving problems presented in two languages. The finding was that a smaller proportion of subjects suceeded in solving a problem completely in a second language than in a first language despite subjects having understood the sentences of problems equally well in both languages.

A final study to be discussed in this section by d'Anglejan and Tucker (1975) deserves detailed attention because it focused on logical reasoning skills of adult Canadian French-English bilinguals as related to logical reasoning problems that are very similar to problems used for the current research. The d'Anglejan and Tucker study involved two groups of male military personnel attending a Canadian armed forces language school. One group of subjects consisted of individuals who were classified as beginning English students on the basis of elaborate diagnostic tests of reading, writing, oral comprehension, and oral production of English, while the other group of subjects were classified as advanced English students on the basis of the same proficiency tests. The results of the study showed that both beginning and advanced English students made more errors in solving three-term syllogistic reasoning problems in their second language--English--than in their first language--French. Furthermore, there were no significant differences between beginning and advanced English students in solving English syllogism problems despite the clear difference in their proficiencies in English; in addition, there was no significant interaction effects on performance due to the language of testing factor and the skill in English factor. An analysis of latency of problem solution showed that subjects generally took longer to solve syllogisms in a second language than in a first language with advanced English students taking less time than beginning English students; however, no test of statistical significance is reported for these differences.

While these results appear clear-cut, a methodological flaw in the research procedure led to an exclusion of syllogism problems in English which were found to be too difficult for many beginning English students. In addition those beginning English students who were unable to solve the difficult syllogisms were also removed from the study, thus leading to an overall attenuation of the influence of proficiency skills in a second language on logical reasoning test performance.

Goals of the Present Study and Past Research

An overview of past research on bilingualism and cognition suggests that much new work is needed on better understanding language and cognitive process variables which underlie performance on high level reasoning tasks stated in two languages. From the viewpoint of the current project, such work should begin by focusing on how well bilinguals from a single ethnolinguistic group--here Puerto Ricans--perform problem solving tasks in Spanish and English in relation to reading skills in both languages. Rather than contrasting Puerto Ricans' performance in problem solving in a language to performance of monolingual groups in either Spanish or English, it was decided to investigate the variation of logical reasoning problem solving skills within Puerto Rican college students--as a single group in relation to variation in comprehension skills in either Spanish or English separately. Such an approach was chosen because it would offer the opportunity to expend additional research resources on investigating whether background differences among bilingual Puerto Rican college students in the U.S. might be linked to differences in schooling and language experiences in the U.S. mainland versus Puerto Rico in a way that would not be mediated through simple reading comprehension skills in Spanish and English.

While a substantial portion of the research which has been reviewed (e.g. Kolers, 1966; Lambert et al, 1959, International Institute of Teachers College, Columbia University, 1926; Macnamara, 1967; Macnamara and Kellaghen, 1968; Mahakian, 1938; Sanchez, 1934; Darcy, 1952) stressed the finding that bilinguals perform problem solving better in a first language than in a second language such a view is simplistic at best as a working hypothesis to investigate in the case of cognitive problem solving by Puerto Rican college subjects in the current study. The reason for this is that while greater than ninety percent of all Puerto Ricans report Spanish as a first language and English as a second language, exposure to Spanish and English as a language for schooling prior to entrance to college on the U.S. mainland is much more varied and may indeed be a more initial factor in being able to solve reasoning problems more familiar to school contexts than other community or home environments. Thus in the current study number of years schooled in Spanish and English in either Puerto Rico or the mainland U.S. served as critical background language variables in contrast to order of acquisition of Spanish and English.

The most striking findings of past research of relevance to the current study are those of Kolers, 1966; Lambert et al, 1959; Macnamara, 1967; and Macnamara and Kellaghen, 1968 which stress the importance of component reading comprehension skills in efficiency of solving problems or executing tasks stated in a second language. As was mentioned earlier, in the current study the distinction between first and second language may be less important than educational exposure to languages during schooling. Accordingly in the current study it was hypothesized that regardless of

language used to state reasoning problems certain reading comprehension skills would be found to be predictive of reasoning task performance.

Description of Logical Reasoning Tests

The criterion logical reasoning problems used in the current study were adopted from existing English language versions of psychometric instruments. The following is a description of these instruments. The four logical reasoning tests chosen for use were found to form a single psychometric factor in factor analytic studies carried out by French, Ekstrom and Price (1963) and Ekstrom, French and Harman (1977); the term "logical reasoning" as a referent to the common properties of these tests was judged as the most appropriate label by Ekstrom, French and Harman (1976), given other less suitable alternatives such as "syllogistic reasoning" or "deductive reasoning." Each of the four tests requires subjects to reason from premises to a conclusion or to evaluate the correctness of a conclusion. Previous research on the relationship of logical reasoning skills as conceived here has been found by a number of researchers to be significantly associated with the comprehension of textual materials and inferencing based on such materials (Hildyard & Olson, 1978; Pettit & Cockriel, 1974; Thorndike, 1973). Thus the logical reasoning skills selected for study in the proposed research have a natural bearing on learning more about how skills basic to the reading literacy of bilinguals differ as a function of language of materials.

The logical reasoning test with minimal linguistic processing requirements is the Diagramming Relations test which presents subject with sets of three nouns such as:

dogs, mice, animals

which then must be matched against one of three diagrams of the form:

that captures the category relationships among the classes of concrete objects referred to by nominal terms. In the case of the problem given, the middle diagram is the correct solution since dogs and mice are both animals but are distinct from each other. In terms of linguistic processing this test thus requires only recognition of isolated words.

In the Nonsense Syllogisms test subjects are presented with a hypothetical three-term syllogism such as:

All trees are fish. All fishes are horses.

Therefore all trees are horses.

Subjects are requested to respond G (good) or P (poor) in a multiple-choice format based on whether the argument is valid or not if the first two terms are assumed true, regardless of their pragmatic deficiencies. Linguistically this test requires subjects to understand the syntactic form of a sentence and the meaning of terms of quantification, logical entailment and predication of properties of objects. Notice that there is a strong similarity between the kinds of judgments subjects are asked to make in this test and on the earlier Diagramming Relations test.

The Logical Reasoning, Form A test is essentially identical to the Nonsense Syllogisms test in format, reasoning, and linguistic processing requirements, except that three-term syllogisms have valid pragmatic references to the properties of object; i.e., the terms aren't nonsensical.

The fourth logical reasoning instrument, known as the Inference Test, presents subjects with statements of the form:

> All human beings fall into four main groups according to the composition of their blood: O, A, B, and AB. Knowledge of these blood types is important for transfusions.

On the basis of these statements subjects are required to select the unique correct conclusion that logically follows from a set of alternatives such as:

> 1-The blood type is determined by genes.
>
> 2-Persons of group AB can receive blood from any other type.
>
> 3-Blood transfusions between members of the same group are always safe.
>
> 4-Certain percentages of all people belong to each type. (Correct answer)
>
> 5-Blood from persons of group O can safely be given to persons of any group.

Subjects are instructed to choose only that conclusion which follows from the original information given without bringing in other knowledge or beliefs not made explicit originally. Linguistically, this class of logical reasoning problems requires more extensive discourse comprehension and manipulation of syntactic and semantic information than the three previous tests mentioned.

Plan of Research

In the current study each of the four tests of logical reasoning described above was translated into a Spanish equivalent using a translation

procedure described in the Methods section. The plan of research entailed administering subjects both Spanish and English versions of each of the four tests along with separate tests of Spanish and English reading comprehension and a background questionnaire focusing on schooling and language experience in the U.S. and Puerto Rico. The Spanish and English versions of logical reasoning tests were altered from the original English format so as to permit collection of reading comprehension performance right while a test was being administered. Measures collected during reasoning test administration included 1) average time for the first reading of items on a test; 2) number of times mental translation occurred from the language of items to the other language; 3) number of lexical terms on items making up a test which were not clearly understood; and 4) number of complete sentences not understood on items making up two of the four reasoning tests administered. On the basis of previous research it was hypothesized that these measures would be significantly related to reasoning test performance as a function of the linguistic demands of reasoning tests.

While measures of reading comprehension performance collected during reasoning test administration were hypothesized to be direct evidence of reading skill influence on test performance in either language, more global reading comprehension scores obtained on separate reading tests in Spanish and English were hypothesized to also be related to performance on reasoning tests in a language to the extent that general comprehension facility in a language interacts with cognitive performance on reasoning tasks in a way not captured by direct evidence of reading efficiency while working reasoning problems. The tactic used in analysing this

relationship was to examine how well reasoning test performance that could not be predicted statistically alone by reading measures during logical reasoning testing might be predicted statistically by scores on comprehension tests in each language.

The function of background questionnaire data concerning languages of schooling and exposure to language in the U.S. mainland and Puerto Rico was to learn whether additional unpredicted variance in reasoning test performance in either language might be linked to these background differences independent of the influence of the two classes of reading comprehension described. Information of this latter sort would be useful in detecting whether reasoning performance might indeed be related to differences in the schooling and experience of Puerto Rican subjects with the types of reasoning problems presented on tests.

The second major research question posed in the current project was whether there was evidence that skills in logical reasoning as represented by the problems occurring on reasoning tests in either language might be parsimoniously conceived as representing a common skill across the two languages used to state problems and that comprehension skills in Spanish and English were distinct. Two alternative hypothesis were a) that only one general intellectual skill underlies both reading comprehension ability in both languages and reasoning skills in both languages or b) that reasoning skills in Spanish along with comprehension skills in Spanish are distinct from the same, separate skills in English. The tactic used in investigating the second major research question was confirmatory factor analysis. The measures included in this procedure were all scores on Spanish and English logical reasoning tests and all

scores on the generalized reading comprehension tests in Spanish and English.

The third major research question posed in the present project was how level of performance on matched pairs of logical reasoning tests in Spanish and English differed according to the reading comprehension proficiency profile of Puerto Rican subjects in both Spanish and English. For purposes of simlicity a strategy was used to categorize Puerto Rican subjects into four bilingual reading comprehension classes: Low Spanish-Low English; Low Spanish-High English; High Spanish-Low English; and High ?Spanish-High English. Correlated means t-test procedures were then used to compare performance on Spanish versus English version tests within each classification.

CHAPTER II

Method

Subjects

Two hundred nine Puerto Rican students enrolled in approximately 21 colleges in the states of Connecticut, New York, New Jersey, Pennsylvania and Virginia served as paid subjects at the rate of $20.00 for a single four and one half hour testing session. The predominant majority of students, 175 out of 209 (83.7 percent) were verified as enrolled in four year institutions on the basis of background questionnaire data. Twenty-five students (12 percent) were verified as enrolled in two year institutions, while 9 subjects (4.3 percent) did not identify whether their current or entering college was a two year or four year institution.

Recruitment of subjects at each institution was conducted by one or more student recruiters who were paid $4.00 for each student participating. Responsibilities of recruiters included arrangements for testing room and date and time of testing. Prior to recruitment research assistants on the current project negotiated permission to run the study at school sites where this proved necessary. The typical pattern in recruitment of subjects involved simultaneously contacting a college administrator or teacher involved in Puerto Rican affairs and a Puerto Rican student organization on campus. In many instances recruiters were themselves representatives of Puerto Rican student organizations on campus, in which case recruitment funds were donated by recruiters to the Puerto Rican organization.

Subjects participating in the study were asked to sign a standard consent and receipt of payment form indicating the nature of the study, rate of pay and guarantee of anonymity as well as the right to withdraw from testing without notice should discomfort arise.

Logical Reasoning Instruments and Assessment of Reading Comprehension on Reasoning Instruments

The design of logical reasoning tests in the current study was based on four reasoning tests, Diagramming Relationships Nonsense Syllogisms, Inference Test and Logical Reasoning drawn from French, Ekstrom and Price (1963) and Ekstrom, French and Harman (1976). Items from each of the two parts of the aforementioned instruments were used to construct eight new instruments, each in two parallel forms in either Spanish or English. The resulting instruments were named Spanish Diagramming Relationships, Spanish Nonsense Syllogisms, Spanish Inference Test and Spanish Logical Reasoning in their Spanish renditions. Instruments in English were labeled accordingly, using the same format. As mentioned, two parallel forms for each instrument were constructed in each language. These forms consisted of either exclusively part one, or part two items in the same language drawn from the original instruments.

Apart from shortened length and possible occurrence in Spanish rather than English the eight instruments in the current study differed from the original instruments by inclusion of three or four tasks not found on the originals. These tasks included:

- Noting down time in hours, minutes and seconds from a Heathkit model GC-1092D digital clock at the start and end of the first reading of each test item.

- After working an item, checking the answer "Yes" or "No" to a question inquiring whether a subject was aware of thinking in a language different from that used to state an item or aware of deliberate mental translation of an item from one language to another.
- After working an item, underlining words in the item not understood in context or not understood clearly.
- After working an item consisting of complete, meaningful sentences, placing a question mark after each sentence not understood fully in context.

The objective of these tasks was to gain evidence regarding reading comprehension facility in Spanish or English right while reasoning problems were being worked. In accordance with these task demands total time allotted for completion of items on a test was increased by 1.5 to 2 times the total time allotted to work items on the original test versions.

Translation of English language items into Spanish for all instruments was done in stages. In the first stage a Mexican national graduate student in psychology experienced in professional translation, translated English items into Spanish with instructions to avoid literal translations that were awkward or changed meaning; attention was given to noting vocabulary items that were rare in standard literate Spanish or had a noticeably different meaning in Spanish than in English. In the second stage of translation, the principal investigator who is a bilingual Chicano, English dominant, checked the first translation and suggested minor changes in wording to reflect more common usage of terms in U.S.

spoken Spanish than in literate standard Spanish. Subsequent stages of translation and revisions of translations involved bilingual Puerto Ricans exclusively. In the third stage of translation a Puerto Rican graduate student in the area of sociolinguistics who was judged equivalently proficient in both literate Spanish and English modified the then existing Spanish translations of items to reflect Spanish familiar to most Puerto Rican college students. In the fourth and final stage of translation one of the graduate student research assistants in the current project who was born and raised in Puerto Rico and who was dominant in Spanish reviewed the Spanish translations for intellegibility and suggested revisions which were implemented. The general concensus on the part of the research team following this procedure for translation and pilot testing was that the Spanish version items while not always conforming to the highest standards of idiomatic usage in literate Spanish were intelligible to persons identified as highly proficient and persons identified as marginally proficient in literate Spanish.

Copies of the cover pages of the logical reasoning tests employed in the current study are given in Appendix. The cover pages indicate the instructions subjects were to follow and as well show sample problems contained in each test.

Reading Comprehension Instruments

Comprehension facility in Spanish and English was assessed by administration of the Prueba De Lectura, Nivel 5 - Advanzado - Forma DEs and by the Test of Reading Level 5-Advanced Form CE (Guidance Testing Associates, 1962). Both of these tests were originally developed as

reasonably approximate instruments of advanced reading comprehension proficiency for use on Puerto Ricans (Manuel, 1963). While these instruments are no doubt in need of renorming given the date of their development, currently they are the best available advanced level reading comprehension instruments in Spanish and English in parallel forms. Each comprehension test in a language yields four scores reflecting vocabulary, speed of comprehension, level of comprehension and a composite total score.

The purpose of the reading comprehension tests in each language was to study the dependence of performance on logical reasoning tests in each language in relation to reading comprehension ability in the language of reasoning items.

Background Questionnaire

All subjects were asked fill out a five page questionnaire requesting information concerning basic subject characteristics such as age in years, gender, birthplace; educational background in the U.S. mainland and Puerto Rico including language exposure in schooling; parental socioeconomic status and student career plans; and self evaluation of language proficiency in Spanish and English in different language, educational and social contexts. The purpose of the background questionnaire was to offer information on the characteristics of subjects that might be of value in interpretting logical reasoning test performance not explained by measures of reading comprehension in each language.

Procedure

Data collection conformed to the testing session protocol shown below. Total time alloted for testing was five hours with two 10 minute breaks

and a 45 minute break for lunch. Presentation of logical reasoning test forms and comprehension tests was counterbalanced with regard to order of administration of Spanish versus English version tests so that approximately one-half of all subjects were first tested on a form of an instrument in a given language followed by presentation of a different form of the same instrument in the other language.

Data Collection Protocol

(1) Fill out Background Questionnaire and Consent Form: 15 minutes.

(2) Administer Test of Reading or Prueba de Lectura reading comprehension test: 41 minutes.

(3) 10-minute break.

(4) Administer remaining reading comprehension test from (2): 41 minutes.

(5) Administer Nonsense Syllogisms test in English or Spanish: 15 items; 6 minutes.

(6) Administer Nonsense Syllogisms test in other language: 15 items; 6 minutes.

(7) Lunch Break: 45 minutes.

(8) Administer Logical Reasoning test in English or Spanish: 20 items; 12 minutes.

(9) Administer Logical Reasoning test in the other language: 20 items; 12 minutes.

(10) Administer Diagramming Relationships test in English or Spanish: 15 items; 6 minutes.

(11) Administer Diagramming Relationships test in the other language: 15 items; 6 minutes.

(12) 10 minute break.

(13) Administer Inference Test in English or Spanish: 10 items; 10 minutes.

(14) Administer Inference Test in the other language: 10 items; 10 minutes.

CHAPTER III

Results

Characteristics of Subjects

The following description of subjects is offered to facilitate interpretation of the main results of the current work. Of the 209 subjects 99 were males while 110 were females. Average age of subjects was 22.83 years. 122 or 58.4 percent of all subjects were born on the mainland U.S. while 85 or 40 percent of all subjects were born on Puerto Rico. Two subjects were born outside the U. S. On the average subjects had lived over 8.5 years in Puerto Rico and 14.3 years on the United States mainland.

Prior to college subjects, overall, averaged 4.3 years of schooling on Puerto Rico and 7.7 years of schooling on the U. S. mainland. 74 of the 209 subjects (35.4 percent) attended primary school on Puerto Rico while 109 subjects (52.2 percent) attended primary school on the U. S. mainland. 25 subjects (12 percent) attended primary school in both Puerto Rico and the U. S. mainland.

Sixty-eight out of 209 subjects (32.5 percent) attended intermediate school (junior high school or grades 7 through 9) only on Puerto Rican. Only 7 out of 209 subjects (3.4 percent) attended intermediate school on both the island of Puerto Rico and the U. S. mainland.

Number of subjects attending high school only on Puerto Rico was 54 (25.8 percent) while 146 subjects (69.9 percent) reported attending high school only on the U. S. mainland. Only 3.8 percent of all subjects reported attending high school on both Puerto Rico and the U. S. mainland.

With regard to parent's background, 98.8 percent of all fathers and 93.3 percent of all mothers were born on Puerto Rico with the remaining parents being born on the U.S. mainland with 18 exceptions.

The primary language of communication between subjects and their parents was Spanish (76.1 percent) with only 3.8 percent indicating that they spoke to their parents only in English and 18.7 percent of all subject indicating that they spoke customarily to parents in either language with no overwhelming preference for one language over the other.

54.1 percent of all subjects indicated that they spoke both Spanish and English in conversation with their Hispanic friends, while 24.4 percent spoke only Spanish and 20.4 percent spoke only English among their Hispanic friends.

47.8 percent of all subjects judged that they were more proficient in reading English than reading Spanish with roughly equal numbers (24.9 percent and 26.3 percent) indicating that they respectively read best in Spanish or that they read equally well in both languages.

Discussion in subsequent parts of the Results section will focus on the relationship of selected background characteristics of subjects to performance on logical reasoning tests admnistered in both Spanish and English.

Psychometric Characteristics of Test Data

Tables 1 and 2 display the mean score, standard deviation of scores and coefficient α reliability estimates of scores on forms 1 and 2 of each of the four pairs of logical reasoning tests in Spanish and English. The means and standard deviations and estimated reliabilities of forms of tests in a given language are reasonably homogeneous. Coefficient α reliability estimates for the various tests ranged from the low forties to high seventies and low eighties. While these reliability estimates are quite low for purposes of applied psychometric purposes they are considered acceptable evidence that the logical reasoning instruments in the current study do possess adequate internal coherence for interpretaton given the exploratory character of the research questions posed. In all subsequent discussions of the results, reference to logical reasoning tests in a given language will focus on pooled scores across the two forms in a language for each test.

Table 3 displays means, standard deviations and estimated coefficient α reliability estimates for scores on the test of Spanish reading comprehension--Preuba de Lectura, Nivel 5-Advanzado and on the test of English reading comprehension--Test of Reading, Level 5-Advanced Form. Coefficient α reliability estimates across all subscores on tests in either language were excellent ranging from the low eighties to low nineties.

Table 4 displays intercorrelations among all logical reasoning test scores in Spanish and English, and subscores on the Spanish and English reading comprehension tests. The interpretation of patterns of correlations among logical reasoning test scores and comprehension test

TABLE 1

MEANS, STANDARD DEVIATIONS AND ESTIMATED RELIABILITY COEFFICIENTS OF SCORES ON LOGICAL REASONING TESTS IN SPANISH[a]

Test	Form	Number of Items	Mean Score	Standard Deviation	Coefficient α Reliability Estimate
Spanish Nonsense Syllogisms	1	15	6.67	2.44	.49
	2	15	7.09	2.46	.43
	1 and 2 pooled	15	6.92	2.42	---
Spanish Diagramming Relationships	1	15	5.14	2.80	.63
	2	15	5.77	2.77	.45
	1 and 2 pooled	15	5.45	2.54	---
Spanish Inference Test	1	10	3.26	2.01	.51
	2	10	4.28	2.14	.58
	1 and 2 pooled	10	3.80	2.18	---
Spanish Logical Reasoning	1	20	7.49	3.69	.70
	2	20	7.59	4.40	.77
	1 and 2 pooled	20	7.48	3.89	---

[a]N = 98 subjects for Form 1 tests and N = 111 for Form 2 tests.

TABLE 2

MEANS, STANDARD DEVIATIONS AND ESTIMATED RELIABILITY COEFFICIENTS OF SCORES ON LOGICAL REASONING TESTS IN ENGLISH[a]

Test	Form	Number of Items	Mean Score	Standard Deviation	Coefficient α Reliability Estimate
English Nonsense Syllogisms	1	15	7.07	2.31	.40
	2	15	7.72	2.54	.50
	1 and 2 pooled	15	7.33	2.44	---
English Diagramming Relationships	1	15	5.36	2.72	.61
	2	15	6.32	3.51	.79
	1 and 2 pooled	15	5.80	3.22	---
English Inference Test	1	10	3.74	2.08	.53
	2	10	4.70	2.47	.70
	1 and 2 pooled	10	4.21	2.33	---
English Logical Reasoning	1	20	8.80	4.10	.75
	2	20	8.72	4.81	.83
	1 and 2 pooled	20	8.73	2.92	---

[a]N = 111 subjects for Form 1 tests and N = 98 for Form 2 tests.

TABLE 3

MEANS, STANDARD DEVIATIONS AND ESTIMATED RELIABILITY COEFFICIENTS OF SUBSCORES AND TOTAL SCORES ON SPANISH AND ENGLISH READING COMPREHENSION TESTS[a]

Test	Subscore or Total Score	Number of Items	Mean Score	Standard Deviation	Subscore Coefficient α Reliability Estimate
Prueba de Lectura, Nivel 5-Advanzado	Spanish Vocabulary	45	22.74	9.55	.93
	Spanish Speed	30	8.23	5.55	.88
	Spanish Level	50	17.46	7.56	.88
	Spanish Total	125	48.47	20.72	---
Test of Reading, Level 5 - Advanced Form	English Vocabulary	45	25.58	10.81	.94
	English Speed	30	11.95	5.64	.88
	English Level	50	21.78	9.12	.91
	English Total	125	59.45	23.61	---

[a]N = 209 subjects

TABLE 4

CORRELATIONS AMONG LOGICAL REASONING TEST SCORES AND COMPREHENSION SUBSCORES FOR BOTH LANGUAGES

	Spanish Nonsense Syllogisms	Spanish Diagramming Relationships	Spanish Inference Test	Spanish Logical Reasoning	English Nonsense Syllogisms	English Diagramming Relationships	English Inference Test	English Logical Reasoning	Spanish Vocabulary	Spanish Speed	Spanish Level	English Vocabulary	English Speed	English Level
Spanish Nonsense Syllogisms	1.00													
Spanish Diagramming Relationships	.25	1.00												
Spanish Inference Test	.06	.52	1.00											
Spanish Logical Reasoning	.16	.48	.43	1.00										
English Nonsense Syllogisms	.18	.24	.10	.16	1.00									
English Diagramming Relationships	.10	.54	.35	.42	.25	1.00								
English Inference Test	.10	.50	.49	.48	.19	.51	1.00							
English Logical Reasoning	.14	.57	.50	.68	.28	.55	.58	1.00						
Spanish Vocabulary Spanish Speed	.05	.48	.49	.47	.07	.35	.47	.37	1.00					
Spanish Speed	.16	.44	.49	.45	.19	.36	.42	.39	.74	1.00				
Spanish Level	.07	.52	.48	.44	.18	.47	.49	.45	.74	.72	1.00			
English Vocabulary	.07	.53	.54	.47	.17	.51	.68	.55	.71	.52	.60	1.00		
English Speed	.14	.54	.56	.45	.22	.53	.60	.55	.61	.61	.58	.81	1.00	
English Level	.07	.56	.60	.49	.21	.59	.66	.60	.54	.46	.59	.77	.76	1.00

scores is deferred until the portion of the Results section on factor analysis which explores the plausibility of concluding that all reasoning tests regardless of language are measuring a single underlying cognitive ability which is distinct from separate comprehensions skills in each language.

The Influence of Reading Comprehension Performance During Reasoning Test Administration on Logical Reasoning Test Scores

This section describes how performance on each of the four pairs of tests of logical reasoning in Spanish and English was related to four measures of reading performance obtained right while tests were being administered. The four measures of reading performance which were obtained were: (1) Average Reading Time Per Item; (2) Number of Times Used the Other Language (while working a test); (3) Number of Words Not Understood (on a test); and (4) Number of Sentences Not Understood (on a test). Means and standard deviations for these measures on all four pairs of reasoning tests in Spanish and English are given in Tables 5 and 6. A measure of Number of Sentences Not Understood was omitted for the Spanish and English versions of the Nonsense Syllogisms and Diagramming Relationships tests since such a measure was not meaningful given the format of these two tests.

Correlations between performance on each logical reasoning test in Spanish and English and measures of reading performance during testing are shown in Tables 7 and 8. Consistent with hypothesis, Average Reading Time Per Item bore a significant negative relationship with performance on all logical reasoning tests regardless of the language of testing.

TABLE 5

MEANS AND STANDARD DEVIATIONS OF MEASURES OF READING PERFORMANCE ON LOGICAL REASONING TESTS IN SPANISH

Measure of Reading Performance on a Test	TEST SCORE							
	Spanish Nonsense Syllogisms		Spanish Diagramming Relationships		Spanish Inference Test		Spanish Logical Reasoning	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Average Reading Time Per Item	13.87	4.96	9.47	4.38	15.87	7.10	10.36	5.05
Number of Times Used English	1.75	3.50	2.02	4.33	1.28	2.82	2.46	5.38
Number of Words Not Understood	.77	2.16	.71	1.97	.79	2.50	.85	2.31
Number of Sentences Not Understood	---	---	---	---	.22	.91	.22	1.20

TABLE 6

MEANS AND STANDARD DEVIATIONS OF MEASURES OF READING PERFORMANCE ON LOGICAL REASONING TESTS IN ENGLISH

Measure of Reading Performance on a Test	TEST SCORE							
	English Nonsense Syllogisms		English Diagramming Relationships		English Inference Test		English Logical Reasoning	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Average Reading Time Per Item	11.80	4.77	8.77	4.89	12.84	5.82	9.21	5.27
Number of Times Used English	1.22	3.18	1.27	3.25	.96	2.40	2.17	5.16
Number of Words Not Understood	.08	.52	.11	.70	.28	1.45	.47	3.54
Number of Sentences Not Understood	---	---	---	---	.11	1.13	.22	2.27

TABLE 7

CORRELATIONS BETWEEN LOGICAL REASONING TEST SCORES IN SPANISH AND MEASURES OF READING PERFORMANCE DURING TEST ADMINISTRATION

Measure of Reading Performance on a Test	TEST SCORE			
	Spanish Nonsense Syllogisms	Spanish Diagramming Relationships	Spanish Inference Test	Spanish Logical Reasoning
Average Reading Time Per Item	-.14*	-.15*	-.24*	-.20*
Number of Times Used English	.04	-.14*	-.15*	-.02
Number of Words Not Understood	-.11	.03	.01	.00
Number of Sentences Not Understood	---	---	-.10	-.12*

*Significant at $p \leq .05$; $205 \leq N \leq 209$ subjects.

TABLE 8

CORRELATIONS BETWEEN LOGICAL REASONING TEST SCORES IN ENGLISH AND MEASURES OF READING PERFORMANCE DURING TEST ADMINISTRATION

Measure of Reading Performance on a Test	TEST SCORE			
	English Nonsense Syllogisms	English Diagramming Relationships	English Inference Test	English Logical Reasoning
Average Reading Time Per Item	-.22*	-.25*	-.22*	-.22*
Number of Times Used Spanish	-.08	-.16*	-.14*	-.22*
Number of Words Not Understood	-.02	.11	-.01	-.13*
Number of Sentences Not Understood	---	---	-.08	-.15*

*Significant at $p \leq .05$; $205 \leq N \leq 209$ subjects.

on all logical reasoning tests regardless of the language of testing. The second most important reading performance constraint on reasoning test performance was Number of Times Used the other language during problem reading and problem solution. This measure was associated at a statistically significant level with logical reasoning performance for two out of four tests in Spanish and three out of four tests in English. Number of Words Not Understood was significantly related according to hypothesis to performance on the Spanish Logical Reasoning test. In English this measure was significantly related to reasoning performance also, only in the case of the English Logical Reasoning test. Number of Sentences Not Understood was significantly related according to hypothesis to performance on Spanish Logical Reasoning and English Logical Reasoning tests.

The composite importance of measures of reading performance during logical reasoning testing for predicting scores obtained on reasoning tests in each language was assessed by means of multiple regression analysis. The results of these analyses for each test and language are shown in Tables 9 and 10.

For logical reasoning tests in Spanish, the results of multiple regression analyses (Table 10) showed that performance on the Spanish-Diagramming Relationships and the Spanish Inference test was significantly predictable from a linear composite of reading performance measures during testing beyond chance at $p < .005$ and $p < .01$ levels respectively. The results of these analyses also showed that .15 percent and .13 percent of the total variability in these two reasoning tests respectively

TABLE 9

MULTIPLE REGRESSION ANALYSES: SCORES ON LOGICAL REASONING TESTS IN SPANISH IN RELATION TO READING PERFORMANCE DURING TESTING

Independent Variables	DEPENDENT VARIABLE											
	Spanish Nonsense Syllogisms			Spanish Diagramming Relationships			Spanish Inference Test			Spanish Logical Reasoning		
	Beta	F(1,104)	P	Beta	F(1,104)	P	Beta	F(1,103)	P	Beta	F(1,103)	P
Average Reading Time Per Item	-.07	.52	n.s.	-.27	8.27	<.01	-.31	11.52	.001	-.31	10.75	<.005
Number of Times Used English	-.02	.06	n.s.	-.30	10.21	<.005	-.11	1.37	n.s.	.01	.02	n.s.
Number of Words Not Understood	-.17	3.10	<.05	-.02	.04	n.s.	.08	.08	n.s.	.05	.21	n.s.
Number of Sentences Not Understood	---	---	---	---	---	---	-.11	.33	n.s.	.03	.10	n.s.

REGRESSION STATISTICS

R_2	.19	.38	.36	.32
R^2	.04	.15	.13	.10
F	1.30	6.02	3.75	2.94
df	3,104	3,104	4,103	4,103
P	n.s.	<.005	<.01	<.10

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TABLE 10

MULTIPLE REGRESSION ANALYSES: SCORES ON LOGICAL REASONING TESTS IN ENGLISH IN RELATION TO READING PERFORMANCE DURING TESTING

Independent Variables	DEPENDENT VARIABLE: English Nonsense Syllogisms			English Diagramming Relationships			English Inference Test			English Logical Reasoning		
	Beta	F(1,101)	P	Beta	F(1,101)	P	Beta	F(1,101)	P	Beta	F(1,100)	P
Average Reading Time Per Item	-.33	13.20	<.001	-.42	23.48	.001	-.29	8.93	<.01	-.31	11.72	<.005
Number of Times Used English	-.09	1.01	n.s.	-.18	3.84	<.10	-.13	1.92	n.s.	-.22	5.55	<.025.
Number of Words Not Understood	-.02	.03	n.s.	-.04	.18	n.s.	.09	.89	n.s.	.08	.68	n.s.
Number of Sentences Not Understood	---	---	---	---	---	---	.22	5.01	<.05	-.07	.56	n.s.

REGRESSION STATISTICS

R_2	.35	.47	.37	.41
R^2	.12	.22	.14	.16
F	4.88	9.72	4.06	5.07
df	3,104	3,104	4,103	4,103
P	<.005	<.001	<.01	<.005

was predictable from variation in linear composites of reading performance measures on each test. Average Reading Time Per Item contributed significantly ($p < .01$ and $p < .001$) to prediction of scores on each of the two respective reasoning tests in the expected negative direction. In addition on the Spanish Diagramming Relationship test, Number of Times Used English was a significant contributor to predicting reasoning performance in the expected negative direction ($p < .005$).

Multiple regression analyses in the case of the Spanish Logical Reasoning test showed a marginally significant relation ($p < .10$) between test scores and a linear composite of reading performance measures during logical reasoning test administration. The variance in test scores that was accounted for by reading measures during testing for this instrument amounted to only 10 percent of the total variance, this predictive strength being largely attributable to the Average Reading Time Per Item which had a regression coefficient that differed from zero beyond chance at the $p < .005$ level.

Prediction of performance on the Spanish Nonsense Syllogisms test was not significant in terms of a linear combination of measures of reading performance during reasoning testing, though Number of Words Not Understood did contribute beyond the chance level to whatever value lay in these reading during testing measures for predicting reasoning test performance.

Table 10 displays the results of multiple regression analyses of logical reasoning test scores in English in relation to predictor measures of reading performance during administration of each test. The results

of these analyses are consistent with the results shown for Spanish tests with a couple of exceptions. In contrast to the results for Spanish reasoning tests, in the case of the English version reasoning tests, all four rather than just three sets of test scores were significantly predictable (at or below the $p < .01$ level) from reading performance measures during reasoning testing. Overall the results indicated that more variance on English reasoning tests was predictable from reading performance measures during testing than was the case for Spanish version tests, but the total predictable variance still averaged below twenty percent of the total variance for tests. As was the case with reasoning tests in Spanish, the most significant predictor of test performance in English was Average Reading Time Per Item ($p < .01$ for all four tests). In the case of the English reasoning tests, Number of Times Used Spanish contributed significantly to the prediction of scores on the English Diagramming Relationships test and the English Logical Reasoning test. In another instance, Number of Sentences Not Understood was found to be a significant predictor of performance on the English Inference Test ($p < .05$), but the positive sign of the corresponding regression coefficient violates the expected direction of sign according to the hypothesis that poorer comprehension of sentences should reduce the chances of working logical reasoning problems correctly.

While the results of the regression analyses of logical reasoning test performance in Spanish and English in relation to reading performance measures generally conform to hypotheses, the strongest hypothesis which was originally proposed regarding these relationships was not supported.

According to this hypothesis within a language as the language processing demands of reasoning tasks increases among the various tests (from simple word recognition on the Diagramming Relationships tests, to simple sentence comprehension on the Nonsense Syllogisms and Logical Reasoning tests, to comprehensions of text on the Inference Test) the strength of prediction of reading performance measures should increase. This hypothesis was clearly not supported by the results.

Improving Prediction of Logical Reasoning Test Performance By Considering the Contribution of Generalized Reading Comprehensions Skills in Spanish and English

The previous section focused on how well performance on logical reasoning tests in Spanish and English could be predicted from evidence of reading efficiency right during administration of reasoning tests. The current section goes on to explore how well prediction of reasoning performance in each language was improved by considering three generalized reading comprehension skills in each language in addition to reading performance measures during administration of reasoning tests. The three additional measures of reading comprehension in Spanish and English were represented by Vocabulary, Speed and Level subscores on the Prueba De Lectura, Nivel 5- Advanzado-Forma DES and the Test of Reading Level 5--Advanced Form CE comprehension tests. The Vocabulary, Speed and Level subscores on each of these tests was considered to measure generalized comprehension skills in a language because the domain and content of items on the corresponding subtests does not focus on any particular topics. Whereas the previous regression analyses examined the extent to which logical reasoning performance could be predicted from proximal evidence of

reading comprehension efficiency while working reasoning tests, the present regression analyses investigated how well such prediction could be improved by assessing general comprehension competencies in the areas of vocabulary, speed of comprehension, and level of comprehension.

There is some overlap in measures of comprehension during reasoning testing and on general comprehension tests in each language which needs comment in relation to the analyses to be discussed. While it may seem natural to project that the most important reading measures to consider in predicting reasoning test performance are those which are most proximal--i.e., those obtained during reasoning testing, quite the contrary result might emerge consistent with a hypothesis that global proficiency in a language has a facilitative effect on problem solving in a language which is difficult to trace in terms of highly specific reading efficiency measures during problem solving.

Tables 11 and 12 display the results of the new regression analyses predicting performance on each logical reasoning test in Spanish and English from both measures of reading performance during reasoning test administration, and measures of performance on three subscales of reading comprehension in the same language as reasoning tests.

As shown in Table 11, the pattern of significant prediction of logical reasoning test scores in Spanish is identical to that obtained in the first series of regression analyses on these tests. As before, scores on the Spanish Diagramming Relationships, Spanish Inference Test, and Spanish Logical Reasoning tests were significantly predicted by reading measures in Spanish, the latter now including Vocabulary, Speed and Level subscores on a generalized Spanish reading comprehension test.

TABLE 11

MULTIPLE REGRESSION ANALYSES: SCORES ON LOGICAL REASONING TESTS IN SPANISH IN RELATION TO READING COMPREHENSION PERFORMANCE DURING TESTING AND GENERALIZED READING COMPREHENSION SCORES IN SPANISH

Independent Variables	DEPENDENT VARIABLE: Spanish Nonsense Syllogisms			Spanish Diagramming Relationships			Spanish Inference Test			Spanish Logical Reasoning		
	Beta	F(1,101)	P	Beta	F(1,101)	P	Beta	F(1,101)	P	Beta	F(1,100)	P
Average Reading Time Per Item	-.03	.12	n.s.	<u>-.18</u>	4.55	<.05	<u>-.16</u>	3.43	<.10	<u>-.19</u>	4.82	<.05
Number of Times Used English	-.03	.09	n.s.	-.08	.75	n.s.	.07	.69	n.s.	.14	2.34	n.s.
Number of Words Not Understood	<u>-.18</u>	3.25	<.10	-.01	.00	n.s.	.06	.36	n.s.	.05	.20	n.s.
Number of Sentences Not Understood	---	---	---	---	---	---	.02	.06	n.s.	.01	.00	n.s.
Spanish Vocabulary	<u>-.31</u>	3.44	<.10	<u>-.26</u>	3.82	<.10	<u>.34</u>	6.67	<.025	<u>.28</u>	3.93	<.05
Spanish Speed	<u>.34</u>	4.60	<.05	.09	.42	n.s.	.16	1.41	n.s.	.19	1.83	n.s.
Spanish Level	.02	.01	n.s.	<u>.24</u>	3.34	<.10	.13	.99	n.s.	.07	.27	n.s.
REGRESSION STATISTICS												
R_2	.30			.62			.62			.55		
R^2	.09			.38			.38			.30		
F	2.76			10.38			8.86			6.20		
df	6,101			6,101			7,100			7,100		
P	n.s.			<.001			<.001			<.001		

TABLE 12

MULTIPLE REGRESSION ANALYSES: SCORES ON LOGICAL REASONING TESTS IN ENGLISH IN RELATION TO READING COMPREHENSION PERFORMANCE DURING TESTING AND READING COMPREHENSION SCORES IN ENGLISH

Independent Variables	DEPENDENT VARIABLE: English Nonsense Syllogisms			English Diagramming Relationships			English Inference Test			English Logical Reasoning		
	Beta	F(1,101)	P	Beta	F(1,101)	P	Beta	F(1,100)	P	Beta	F(1,100)	P
Average Reading Time Per Item	-.32	11.33	<.005	-.32	17.46	<.001	-.14	3.46	<.10	-.23	8.51	<.01
Number of Times Used English	-.03	.12	n.s.	-.07	.70	n.s.	.03	.25	n.s.	-.09	1.20	n.s.
Number of Words Not Understood	-.04	.15	n.s.	.04	.25	n.s.	.13	4.10	<.05.	.09	1.23	n.s.
Number of Sentences Not Understood	---	---	---	---	---	---	.13	3.50	<.10	-.04	.23	n.s.
English Vocabulary	-.01	.00	n.s.	.15	1.54	n.s.	.46	17.83	<.001	.13	1.06	n.s.
English Speed	.04	.07	n.s.	.15	1.61	n.s.	.15	1.73	n.s.	.07	.26	n.s.
English Level	.16	.92	n.s.	.29	4.47	<.001	.15	1.59	n.s.	.39	8.59	<.01

REGRESSION STATISTICS

R_2	.39	.70	.76	.66
R^2	.15	.48	.58	.44
F	3.03	15.75	19.50	11.06
df	6,101	6,101	7,100	7,100
P	<.01	<.001	<.001	<.001

Inspection of R^2 statistics for the first and second series of regression analyses of Spanish reasoning test performance reveals how much more variance in reasoning tests was accounted for as a result of adding in generalized Spanish reading comprehension test subscores into the prediction equations. Comparison of the R^2 statistics across the same reasoning tests shows that two to three times more variance was accounted for in the case of the second series of regression analyses compared to the first. Analyses of the significance of these increments in variance accounted for are shown in Tables 16 and 18 and will be discussed later. The obvious conclusion to be drawn is that understanding how performance on logical reasoning tests in Spanish was constrained by comprehension skills in Spanish need consider both proximal evidence of reading comprehension efficiency and generalized Spanish comprehension proficiency. Based on the degree to which prediction of Spanish logical reasoning test performance was improved by considering comprehension subscores in Spanish, the tentative conclusion can be drawn that these latter measures of comprehension were more important for understanding reasoning performance than the measures of proximal reading comprehension obtained during testing.

Inspection of Table 12 showing the results of the second series of regression analyses for logical reasoning tests in English reveals that scores on all tests were significantly predicted from a linear combination of reading comprehension measures, obtained during reasoning test administration or on a separate test of generalized English reading comprehension.

Comparison of the R^2 statistics indicating the proportion of variance accounted for by the first and second series of regression analyses for English reasoning tests revealed that two to three times more variance in reasoning tests was accounted for by adding-in the contribution of generalized reading comprehension subscores to the contribution for prediction already provided for by proximal measures of reading comprehension performance during reasoning test administration. It does appear to be the case however that five to twenty percent more variance was predicted for on English reasoning tests than on Spanish reasoning tests by measures of reading performance in each language.

It would be valuable to interpret the findings of the regression analyses for Spanish and English reasoning tests thus far discussed more carefully in terms of which generalized reading comprehension measures in each language contribute most significantly to reasoning test performance. Tables 11 and 12 in fact present significant test results on the hypothesis that each regression coefficient is significantly different from zero for every analysis. The relative importance of different generalized reading measures to prediction of reasoning performance however is not undertaken since there are high intercorrelations among these predictor measures. Under these circumstances the estimation of individual regression coefficients for these variables is hypothetically unstable even though the overall, composite strength of prediction of variables is stable when relatively large numbers of subjects are involved, as in the current study.

Improving Prediction of Logical Reasoning Test Performance by Consideration of Background information on Subjects

The purpose of the data analyses reported in this section were to check whether knowledge of a few important background characteristics of Puerto Rican subjects might significantly improve prediction of reasoning test performance in Spanish and English beyond the level reported in the previous section. It should be noted that the study of how background differences influence performance on logical reasoning tests in Spanish or English itself was not the primary focus of research in the current project. However, it is recognized that the meaningfulness of the current project to explore interrelationships between performance on reasoning tests in Spanish and English and reading comprehension skills in both of these languages is ultimately rooted in the linguistic, cultural educational experiences and expectencies of subjects which give rise to the skills measured on any test of cognition or language performance. Given the resources available to the current project it was decided to explore whether just a few background variables of obvious hypothetical import might increase prediction of reasoning test performance in a way not accounted for by the various measures of Spanish and English comprehension introduced in earlier analyses introduced. The background variables considered relevant included number of years lived on Puerto Rico and the U. S. mainland; number of years schooled on Puerto Rico and the U. S. mainland; Puerto Rico versus U. S. mainland location of primary school, intermediate school and high school; language(s) of schooling during primary school, intermediate school and high school; judgment of best reading language; prestige of father's and mother's occupation, and prestige of student's expected profession following college education.

Correlations between scores on Spanish and English logical reasoning tests and numerical variables pertaining to years lived on Puerto Rico or on the mainland U.S.; years schooled on Puerto Rico or the mainland U.S.; prestige of student's planned profession, father's profession and mother's profession are given in Table 13. Prestige ratings for occupations were obtained from the NORC prestige scale (Siegel, 1971). The correlations shown in Table 13 suggest that with the exception of scores on the Spanish Logical Reasoning test, virtually no relationship existed between years of schooling or number of years lived on Puerto Rico and the U.S. mainland and performance on logical reasoning tests in Spanish. In contrast performance on every logical reasoning test in English showed at least one statistically significant relationship to variables representing number of years lived or schooled on Puerto Rico, or on the U.S. mainland. Performance on logical reasoning tests in Spanish showed a universally statistically significant relationship to every single variable marking prestige of planned profession, father's occupation and mother's occupation with one exception. The same pattern of significant relationships between performance on reasoning tests and prestige of occupation variables occurred for English language tests with the exception that prestige of father's and mother's occupation did not significantly associate with performance on the English Nonsense Syllogisms and English Logical Reasoning tests.

Four of the seven numerical background variables considered in Table 13 were elected for inclusion in a third series of multiple regression analyses on Spanish and English logical reasoning tests. The background variables selected were years schooled on Puerto Rico, years schooled on

TABLE 13

CORRELATIONS OF SCORES ON LOGICAL REASONING TEST SCORES IN SPANISH AND ENGLISH WITH SELECTED NUMERICAL BACKGROUND VARIABLES

Background Variable	TEST SCORE							
	Spanish Nonsense Syllogisms	Spanish Diagramming Relationships	Spanish Inference Test	Spanish Logical Reasoning	English Nonsense Syllogisms	English Diagramming Relationships	English Inference Test	English Logical Reasoning
Years Lived in Puerto Rico	-.10	-.07	-.04	.02	-.10	-.17*	-.14*	-.19*
Years Lived on U.S. Mainland	-.02	-.02	.00	-.11*	.02	.05	.11*	.14*
Years Schooled in Puerto Rico	-.11	-.02	.01	.13*	-.11*	-.17*	-.10	-.19*
Years Schooled on U.S. Mainland	.09	-.02	.00	-.11*	.02	.05	.11*	.14*
Prestige of Planned Profession	.18*	.24*	.18*	.21*	.18*	.25*	.25*	.27*
Prestige of Father's Profession	.17*	.28*	.14*	.16*	.07	.16*	.21*	.04
Prestige of Mother's Profession	.14*	.20*	.13*	.09*	.02	.22*	.23*	.08

*Indicates significance at $p < .05$ level.

the U.S. mainland, prestige of father's occupation and prestige of student's expected occupation following termination of college. The strategy of the new regression analyses was to learn whether significant amounts of previously unaccounted for variance on reasoning tests could be predicted by new variables added into regression equations. In the case of the current analyses the old variables included in the regression analyses were the measures of reading comprehension during reasoning testing, and subscores on the generalized reading comprehension test in the language of reasoning tests.

Tables 14 and 15 display the results of this new series of regression analyses on Spanish and English reasoning tests. These results essentially replicate the pattern and significance of prediction already established in the second set of regression analyses discussed in the previous section. Interestingly enough the newly added background variables manifested virtually no significant contribution to reasoning test performance given the language comprehension variables already present in each regression equation. The sole exception to this pattern occurred for predicting performance on the English Logical Reasoning test.

Tables 16 and 17 summarize the outcomes of significance tests of the increment in variance accounted for by adding in new background variables into previous regression equations for predicting reasoning test performance. Also included are significance tests for the increment in accounted for variance resulting from addition of generalized reading comprehension scores to the first series of regression equations which previously only included measures of reading comprehension during reasoning test administration. The information shown in Tables 16 and 17 indicates that consideration of

TABLE 14

MULTIPLE REGRESSION ANALYSES: SCORES ON LOGICAL REASONING TESTS IN SPANISH IN RELATION TO READING COMPREHENSION PERFORMANCE DURING TESTING, GENERALIZED READING COMPREHENSION SCORES IN SPANISH AND SELECTED NUMERICAL BACKGROUND VARIABLES

Independent Variables	DEPENDENT VARIABLE: Spanish Nonsense Syllogisms			Spanish Diagramming Relationships			Spanish Inference Test			Spanish Logical Reasoning		
	Beta	F(1,97)	P	Beta	F(1,97)	P	Beta	F(1,96)	P	Beta	F(1,96)	P
Average Reading Time Per Item	-.03	.11	n.s.	-.19	5.32	<.025	-.20	4.99	<.05	-.19	4.16	<.05
Number of Times Used English	-.04	.12	n.s.	-.08	.69	n.s.	.03	.11	n.s.	.14	2.40	n.s.
Number of Words Not Understood	-.19	3.45	<.10	-.06	.42	n.s.	.05	.23	n.s.	.07	.41	n.s.
Number of Sentences Not Understood	---	---	---	---	---	---	.02	.04	n.s.	-.02	.03	n.s.
Spanish Vocabulary	-.24	1.83	n.s.	.30	4.47	<.05	.36	6.57	<.025	.23	2.28	n.s.
Spanish Speed	.35	4.37	<.05	.16	1.37	n.s.	.21	2.21	n.s.	.17	1.35	n.s.
Spanish Level	-.06	.12	n.s.	.15	1.09	n.s.	.12	.70	n.s.	.10	.44	n.s.
Years Schooled in Puerto Rico	.84	.51	n.s.	-.02	0.00	n.s.	-.29	.09	n.s.	-.43	.47	n.s.
Prestige of Father's Profession	.13	1.34	n.s.	.11	1.49	n.s.	-.04	.17	n.s.	-.07	.47	n.s.
Prestige of Planned Profession	-.10	.88	n.s.	.08	.99	n.s.	.03	.16	n.s.	.15	2.69	n.s.
Years Schooled on the U.S. Mainland	.91	.59	n.s.	.15	.02	n.s.	.11	.01	n.s.	-.52	.25	n.s.

REGRESSION STATISTICS

R	.34	.64	.64	.57
R^2	.11	.41	.41	.33
F	1.24	6.84	6.03	4.21
df	10,97	10,97	11,96	11,96
P	n.s.	<.001	<.001	<.001

TABLE 15

MULTIPLE REGRESSION ANALYSES: SCORES ON LOGICAL REASONING TESTS IN ENGLISH IN RELATION TO READING COMPREHENSION PERFORMANCE DURING TESTING, GENERALIZED READING COMPREHENSION SCORES IN ENGLISH AND SELECTED NUMERICAL BACKGROUND VARIABLES

Independent Variables	DEPENDENT VARIABLE: ENGLISH Nonsense Syllogisms			ENGLISH Diagramming Relationships			ENGLISH Inference Test			ENGLISH Logical Reasoning		
	Beta	F(1,97)	P	Beta	F(1,97)	P	Beta	F(1,96)	P	Beta	F(1,96)	P
Average Reading Time Per Item	-.33	11.31	<.005	-.32	17.04	<.001	-.14	3.25	<.10	-.27	12.33	<.001
Number of Times Used Spanish	-.02	.04	n.s.	-.04	.22	n.s.	.02	.06	n.s.	-.12	2.00	n.s.
Number of Words Not Understood	-.02	.05	n.s.	.04	.88	n.s.	.12	2.85	<.10.	.09	.41	1.47
Number of Sentences Not Understood	---	---	---	---	---	---	.13	3.12	<.10	-.02	.07	n.s.
English Vocabulary	-.03	.04	n.s.	.15	1.42	n.s.	.44	13.74	<.001	.14	1.23	n.s.
English Speed	.03	.04	n.s.	.15	1.37	n.s.	.14	1.59	n.s.	.05	.14	n.s.
English Level	.15	.78	n.s.	.28	4.52	<.05	.15	1.57	n.s.	.35	7.71	<.01
Years Schooled in Puerto Rico	-.20	.03	n.s.	.21	.05	n.s.	-.40	.23	n.s.	.87	1.03	n.s.
Prestige of Father's Profession	.04	.15	n.s.	.02	.02	n.s.	.01	.04	n.s.	-.23	8.12	<.01
Prestige of Planned Profession	.10	.92	n.s.	.02	.02	n.s.	.05	.49	n.s.	.22	7.89	<.01
Years Schooled on the U.S. Mainland	-.13	.01	n.s.	.26	.08	n.s.	-.40	.22	n.s.	.79	.86	n.s.

REGRESSION STATISTICS

R	.41	.70	.76	.71
R^2	.17	.49	.58	.51
F	1.94	9.20	12.07	9.12
df	10,97	10,97	11,96	11,96
P	<.10	<.001	<.001	<.001

TABLE 16

MULTIPLE REGRESSION ANALYSES: IMPROVEMENT IN R^2 IN PREDICTING SCORES ON LOGICAL REASONING TESTS IN SPANISH BY ADDING INDEPENDENT VARIABLES

Classes of Independent Variables in a Regression	DEPENDENT VARIABLE: SPANISH Nonsense Syllogisms			SPANISH Diagramming Relationships			SPANISH Inference Test			SPANISH Logical Reasoning		
	R^2	Increm.	Sig. of Increm.	R^2	Increm.	Sig. of Increm.	R^2	Increm.	Sig. of Increm.	R^2	Increm.	Sig. of Increm.
Reading Performance on Tests	.04	--	--	.15	--	--	.13	--	--	.10	--	--
Reading Performance on Tests + Spanish Reading Comprehension	.09	.05	n.s.	.38	.28	.0005	.38	.25	.0005	.30	.20	.0005
Reading Performance on Tests + Spanish Reading Comprehension + Background Variables	.11	.02	n.s.	.41	.03	n.s.	.41	.03	n.s.	.33	.03	n.s.

TABLE 17

MULTIPLE REGRESSION ANALYSES: IMPROVEMENT IN R^2 IN PREDICTING SCORES ON LOGICAL REASONING TESTS IN ENGLISH BY ADDING INDEPENDENT VARIABLES

Classes of Independent in a Regression	DEPENDENT VARIABLE: ENGLISH Nonsense Syllogisms			ENGLISH Diagramming Relationships			ENGLISH Inference Test			English Logical Reasoning		
	R^2	Increm.	Sig. of Increm.	R^2	Increm.	Sig. of Increm.	R^2	Increm.	Sig. of Increm.	R^2	Increm.	Sig. of Increm.
Reading Performance on Tests	.12	--	--	.22	--	--	.14	--	--	.16	--	--
Reading Performance on Tests + English Reading Comprehension	.15	.03	n.s.	.48	.26	.0005	.58	.44	.0005	.44	.28	.0005
Reading Performance on Tests + English Reading Comprehension + Background Variables	.17	.02	n.s.	.49	.01	n.s.	.58	.00	n.s.	.51	.07	.01

the background variables included in regression contributes only significantly to predicting performance on one reasoning test--English Logical Reasoning; the increment in predicting new variance on all other reasoning tests in both languages is nil.

Turning to consideration of other background variables, Tables 18 and 19 show the results of one-way analyses of variance investigating the relationship of composite scores of performance on logical reasoning tests in Spanish and English to place of schooling (U.S. vs. Puerto Rico vs. Both) at various stages in schooling; language of schooling (Spanish and English vs. English Only) at various stages of schooling; and judgment of best reading language (Spanish vs. English vs. Both).

Language of schooling at various stages of schooling was determined to be both Spanish and English if subjects had been schooled only on Puerto Rico or on both Puerto Rico and the U. S. Mainland. English was judged as the language of schooling if schooling was only on the U. S. Mainland during a stage of schooling prior to college. A more refined attempt to determine exposure to Spanish and English during schooling on Puerto Rico failed due to ambiguities in the background questionnaire used in the current study. The problem resulted from some subjects apparent inability to distinguish between use of English as a medium of instruction versus English taught as a second language as investigated by background questionnaire items. As used in the present report language of schooling may refer to either teaching of normal school topics in a language or to instruction in a language.

TABLE 18

ONE-WAY ANALYSES OF VARIANCE: COMPOSITE LOGICAL REASONING TEST SCORES IN SPANISH IN RELATION TO PLACE AND LANGUAGE OF SCHOOLING, AND JUDGMENT OF BEST READING LANGUAGE

Source	Level	N	Mean	F	df	P
Place of Primary School	Puerto Rico	73	24.23	.33	2,204	.72
	U.S. Mainland	109	23.30			
	Both	25	24.04			
Primary School Language	Spanish and English	101	23.74	.002	1,205	.97
	English	106	23.70			
Place of Intermediate School	Puerto Rico	67	24.58	.66	2,203	.51
	U.S. Mainland	132	23.35			
	Both	7	22.29			
Intermediate School Lanugage	Spanish and English	84	23.58	.04	1,204	.84
	English	122	23.80			
Place of High School	Puerto Rico	53	25.19	2.50	2,204	.08
	U.S. Mainland	146	23.45			
	Both	8	19.00			
High School Language	Spanish and English	82	23.80	.02	1,205	.90
	English	125	23.67			
Judgment of Best Reading Language	Spanish	51	22.75	4.40	2,203	.01
	English	100	22.82			
	Both	55	26.40			

The results of the one way analyses of variance given in Table 18 indicated that schooling on Puerto Rico or schooling in both Spanish and English are not allied by and large with significantly superior performance on Spanish logical reasoning tests over the performance of Puerto Rican subjects schooled only in the U. S. and only in English at various stages of schooling. Judgment of both Spanish and English as the best language of reading, however was allied with superior performance on Spanish logical reasoning tests.

The analyses of variance results given in Table 19, in contrast to the findings just reported indicated that Puerto Rican subjects schooled only on the U. S. Mainland, in English at various stages of schooling performed superior on English Logical reasoning tests in comparison to subjects schooled on Puerto Rico (in both Spanish or English) or on both the U. S. and Puerto Rico in both Spanish and English.

On practical grounds it proved only feasible to investigate the effects of language of high school and judgment of best reading language in the analyses described here. In the procedures followed a set of analyses of covariance were made to investigate whether language of high school and judgment of best reading language could be significantly related to logical reasoning performance on tests in Spanish and English, controlling for the influence of reading comprehension skill in the language of reasoning tests. In conducting the analyses of covariance described here, performance on either Spanish or English logical reasoning tests was determined by summing scores on all reasoning tests in a single language into a single reasoning score for each language. While such a

TABLE 19

ONE-WAY ANALYSES OF VARIANCE: COMPOSITE LOGICAL REASONING TEST SCORES IN ENGLISH IN RELATION TO PLACE AND LANGUAGE OF SCHOOLING, AND JUDGMENT OF BEST READING LANGUAGE

Source	Level	N	Mean	F	df	P
Place of Primary School	Puerto Rico	74	23.80	3.57	2,205	.03
	U.S. Mainland	109	27.27			
	Both	25	27.80			
Primary School Language	Spanish and English	101	24.64	5.61	1,205	.02
	English	106	27.67			
Place of Intermediate School	Puerto Rico	68	23.84	3.59	2,204	.03
	U.S. Mainland	132	27.39			
	Both	7	23.43			
Intermediate School Lanugage	Spanish and English	84	23.99	8.20	1,204	.00
	English	122	27.70			
Place of High School	Puerto Rico	54	23.96	4.73	2,205	.01
	U.S. Mainland	146	27.25			
	Both	8	19.38			
High School Language	Spanish and English	82	24.72	3.46	1,205	.06
	English	125	27.16			
Judgment of Best Reading Language	Spanish	52	22.87	4.34	2,204	.01
	English	100	27.25			
	Both	55	27.18			

procedure is not an optimal one to follow on analytic grounds it was considered adequate given the exploratory character of the study. Similarly for purposes of simplicity, reading comprehension performance in the following covariance analyses was based on the sum of scores on each of the three component subscales on the generalized language comprehension test administered in each language. Measures of reading comprehension efficiency during reasoning test administration were excluded in the current analyses and this did not appear unreasonable given the finding that generalized comprehension scores in a language were much better overall predictors of logical reasoning test performance in either language.

Table 20 shows the results of an analysis of covariance of Total Logical Reasoning Score on Tests in Spanish with Total Reading Comprehension in Spanish and High School Language. Entry 3 of the table shows that there was no statistically significant interaction between levels of High School Language and the covariate of Total Reading Comprehension in Spanish. The absence of a significant interaction in the case of these two factors allowed for interpretation of the remaining effects in the analysis. Total Reading Comprehension in Spanish and High School Language accounted for 37 percent of the variance on the criterion measure--Total Logical Reasoning Score on Tests in Spanish ($p = .00$). Total Reading Comprehension in Spanish alone accounted for 35 percent of the variance on the criterion reasoning score ($p = 0.00$), and High School Language independently accounted for another .02 percent of variance on criterion measure and this latter relationship in itself was statistically significant

TABLE 20

ANALYSIS OF COVARIANCE WITH DEPENDENT VARIABLE: TOTAL LOGICAL REASONING SCORE ON TESTS IN SPANISH; INDEPENDENT VARIABLES: TOTAL READING COMPREHENSION SCORE IN SPANISH (COVARIATE) AND HIGH SCHOOL LANGUAGE

Source	SS	df	F	p	R	R^2
1. Total Reading Comprhension in Spanish and High School Language, including their interaction	4728.28	3	40.25	0.00	.61	.372
2. Total Reading Comprehension in Spanish and High School Language, with no interaction	4702.14	2	60.04	0.00	.608	.370
(a) Total Reading Comprehension in Spanish	4496.84	1	114.84	0.00	.59	.35
(b) High School Language, adjusted for Total Reading Comprehension in Spanish	205.30	1	5.24	<.025	.16	.02
3. Lack of homogeneity of the slope of Total Reading Comprehension in Spanish across levels of High School Language	24.14	1	.67	n.s.	0.04	0.002
4. Error	7988.03	204				

($p < .025$). Computation of the estimated adjusted means on the Total Logical Reasoning Score on Tests in Spanish for each level of the High School Language factor revealed English Only, adjusted mean = 24.52 superior to Both Spanish and English, adjusted mean = 22.43.

Table 21 shows the results of an analysis of covariance of Total Logical Reasoning Score on Tests in English with Total Reading Comprehension in English and High School Language. The preliminary results of this analysis showed no significant interaction between the covariate, Total Reading Comprehension in English and the categorical variable, High School Language thus allowing for further interpretation of the analysis. Examination of the rest of the analysis shows that Total Reading Comprehension in English accounts for about 51 percent of the variance on the criterion measure--Total Logical Reasoning Score in English. The results show that High School Language adds virtually nothing new to prediction of the Logical Reasoning Score in English not already captured by the Total Reading Comprehension in English measure.

Table 22 displays the results of an analysis of covariance of Total Logical Reasoning Score on Tests in Spanish with Total Reading Comprehension in Spanish and Judged Best Language of Reading. The statistical test for interaction between the covariate representing total reasoning score in Spanish and judgments of best language for reading was not significant thus allowing for continuation of the covariance analysis. The results of this extended analysis showed that taken together, Total Reading Comprehension in Spanish and Judged Best Language of

TABLE 21

ANALYSIS OF COVARIANCE WITH DEPENDENT VARIABLE: TOTAL LOGICAL REASONING SCORE ON TESTS IN ENGLISH; INDEPENDENT VARIABLES: TOTAL READING COMPREHENSION SCORE IN ENGLISH (COVARIATE) AND HIGH SCHOOL LANGUAGE

Source	SS	df	F	p	R	R^2
1. Total Reading Comprhension in English and High School Language, including their interaction	9155.84	3	72.01	0.00	.717	.514
2. Total Reading Comprehension in English and High School Language, with no interaction	9059.43	2	106.88	0.00	.7134	.50891
(a) Total Reading Comprehension in English	9053.00	1	213.6	0.00	.7131	.50854
(b) High School Language adjusted for Total Reading Comprehension in English	6.43	1	.15	n.s.	.0192	.0004
3. Lack of homogeneity of the slope of Total Reading Comprehension in English across levels of High School Language	96.41	1	2.27	n.s.	.071	.005
4. Error	8251.57	204				

TABLE 22

ANALYSIS OF COVARIANCE WITH DEPENDENT VARIABLE: TOTAL LOGICAL REASONING SCORE ON TESTS IN SPANISH; INDEPENDENT VARIABLES TOTAL READING COMPREHENSION IN SPANISH (COVARIATE) AND JUDGED BEST LANGUAGE OF READING SCORE

Source	SS	df	F	p	R	R^2
1. Total Reading Comprhension in Spanish and High School Language, including their interaction	4856.62	5	24.96	0.00	.62	.38
2. Total Reading Comprehension in Spanish and Judged Best Language of Reading, with no interaction	4836.13	3	41.43	0.00	.62	.38
(a) Total Reading Comprehension in Spanish	4496.84	1	115.57	0.00	.59	.35
(b) Judged Best Language of Reading, adjusted for Total Reading Comprehension in Spanish	339.29	2	6.80	<.005	.17	.03
3. Lack of homogeneity of the slope of Total Reading Comprehension in Spanish across levels of Judged Best Language of Reading	20.49	2	.26	n.s.	0.00	0.00
4. Error	7859.69	202				

Reading predicted 38 percent of the variance in the criterion variable, Total Logical Reasoning Score on Tests in Spanish ($p = 0.00$). Taken alone, Total Reading Comprehenion in Spanish accounted for 35 percent of the variation on the criterion variable ($p = 0.00$). The effect of Judged Best Language of Reading on criterion scores after controlling for the prediction capability of Total Reading Comprehension in Spanish was 3 percent (p .005). Comparison of the estimated adjusted means on the criterion variable for the Judged Best Language Reading factor showed reading preference in English highest (mean =24.68), preference for reading both in Spanish and English next highest (mean =22.77) and reading preference in Spanish lowest (21.52).

Table 23 reports the outcome of an analysis of covariance on Total Logical Reasoning Score on Tests in English in relation to Total Reading Comprehension in English and Judged Best Language of Reading. A test of the significance of the interaction between the covariate representing reading comprehension in English and judgment of best reading language was not significant indicating appropriateness of continuing the analyses. As expected the covariate Total Reading Comprehension in English contributed significantly to prediction of the criterion available--Total Logical Reasoning Score on Tests in English, with 52 percent of the variance of the criterion accounted for ($p = 0.00$). The results of the analysis of covariance showed that judgment of best reading language did not add significantly to the prediction of the Total Logical Reasoning Score on Tests in English measure above and beyond the influence of the measure, Total Reading Comprehension in English.

TABLE 23

ANALYSIS OF COVARIANCE WITH DEPENDENT VARIABLE: TOTAL LOGICAL REASONING SCORE ON TESTS IN ENGLISH; INDEPENDENT VARIABLES TOTAL READING COMPREHENSION SCORE IN ENGLISH (COVARIATE) AND JUDGED BEST LANGUAGE OF READING

Source	SS	df	F	p	R	R^2
1. Total Reading Comprhension in English and High School Language, including their interaction	9215.24	5	43.36	0.00	.72	.52
2. Total Reading Comprehension in Spanish and Judged Best Language of Reading, with no interaction	9156.42	3	71.80	0.00	.72	.52
(a) Total Reading Comprehension in English	9053.00	1	212.97	0.00	.71	.51
(b) Judged Best Language of Reading, adjusted for Total Reading Comprehension in English	103.42	2	1.19	n.s.	0.00	0.00
3. Lack of homogeneity of the slope of Total Reading Comprehension in English across levels of Judged Best Language of Reading	58.82	2	.69	n.s.	0.00	0.00
4. Error	8586.52	202				

Factorial Structure of Logical Reasoning Test Scores and Reading Comprehension Test Subscores in Spanish and English

The results reported in this section examined the plausability of alternative hypotheses concerning the factorial structure underlying intercorrelations among Spanish and English logical reasoning test scores and subscores on generalized Spanish and English reading comprehension tests.

The first factor structure model that was considered hypothesized that scores on reasoning tests in Spanish and English and on both Spanish and English reading comprehension tests were best thought of as representing one underlying cognitive ability or form of general intelligence and that this construct alone was adequate for explaining intercorrelations among all reasoning and comprehension measures.

A second model which was tested postulated that all the intercorrelations among scores were best explained by positing a single underlying factor representing skills in solving logical reasoning problems regardless of the language in which problems were stated and two further factors which respectively represent Spanish reading comprehension and English reading comprehension.

A third factor model posited two separate logical reasoning factors--one representing ability to solve logical reasoning problems in Spanish and one representing ability to solve logical reasoning prolems in English, plus third and fourth factors respectively representing skills in reading comprehension in Spanish and reading comprehension in English. A fourth factor model which is a variation of the third model was also analysed and is discussed in the present section.

The principal data analysis procedure used was confirmatory maximum likelihood factor analysis; this procedure stems from a general theory for analyzing covariance structures known as ACOVS (Jöreskog, 1970, 1978) implemented on the COFAMM computer program (Sörbom and Jöreskog, 1976). The underlying logic of the confirmatory method of factor analysis allows a researcher to a priori specify permissible factor models underlying an observed correlation matrix and to then go on to statistically test the fit of alternative models based on the ability of these models to reproduce an original correlation matrix under analysis. The confirmatory method of factor analysis thus differs quite substantively from more commonly practiced factor analysis techniques which allow a researcher to specify the number but not the structure of factors to be extracted from a correlation matrix.

Table 24 displays the results of the first factor analysis which posited that only a single cognitive factor underlies performance on all reasoning and comprehension tests. The factor model tested is termed Model 1. The entries of the factor pattern matrix in Table 24 represent the importance of a given kind of test score to the single underlying factor. The magnitude of the entries in the factor pattern matrix indicate that only two measures, Spanish Nonsense Syllogisms and English Nonsense Syllogisms failed to load substantially on the underlying factor. The vector of Uniquenesses represents estimates of variation (scaled between zero and one) for each measure which was not explained by the factor model. It should be noted that the two measures which did not load well on the single posited factor also demonstrated the largest

TABLE 24

MODEL 1 FACTOR ANALYSIS

Variable Number	Variable Name	Factor Pattern Matrix: Factor 1 General Intelligence
1.	Spanish Nonsense Syllogisms	.141
2.	Spanish Diagramming Relationships	.678
3.	Spanish Inference Test	.668
4.	Spanish Logical Reasoning	.613
5.	English Nonsense Syllogisms	.248
6.	English Diagramming Relationships	.636
7.	English Inference Test	.737
8.	English Logical Reasoning	.688
9.	Spanish Vocabulary	.741
10.	Spanish Speed	.677
11.	Spanish Level	.738
12.	English Vocabulary	.870
13.	English Speed	.856
14.	English Level	.847

	1	2	3	4	5	6	7
Uniquenesses:	.980	.541	.554	.624	.939	.595	.457
	8	9	10	11	12	13	14
	.526	.451	.541	.455	.242	.268	.282

Fit of Model: X^2, 77 df = 425.132, p = 0.00

Uniquenesses entries; these same two measures also manifested low coefficient α reliability estimates in relation to other measures.

In determining the adequacy or overall fit of Model 1 it is necessary to further examine an accompanying Chi-square goodness of fit statistic for the model, shown in Table 24, and as well to interpret the magnitude of residual correlations shown in Table 25. The obtained Chi-square with 77 degrees of freedom for Model 1 was 425.132 (p =0.00). Indicating that the model did not fit the data.

The matrix of residual correlations for Model 1 shown in Table 25 represents how well the Model 1 factor analysis was successful in reproducing the original full matrix of intercorrelations among all test scores. Each residual entry represents the difference between an observed correlation between two test scores and the correlation between the same two test scores which was predicted on the basis of the underlying factor model. Inspection of the Model 1 residual correlation matrix of Table 25 showed that while Model 1 did not statistically fit very well on the basis of the obtained Chi-square statistic and p value, that nonetheless the model fit well enough to account for the first one-tenth unit of correlations among almost all variables.

The second factor model which was analyzed--Model 2 postulated that three correlated factors underlay the pattern of intercorrelations among all logical reasoning and language comprehension test scores. According to Model 2, Factor 1 singularly represented ability to solve logical reasoning problems stated in either Spanish or English with no distinction as to the language of problems. Accordingly in specifying

TABLE 25

RESIDUAL CORRELATIONS FOR FACTOR MODEL 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.000													
2	.155	.000												
3	-.034	.068	.000											
4	.076	.068	.020	.000										
5	.142	.067	-.063	.011	.000									
6	.013	.109	-.074	.031	.097	.000								
7	-.001	-.001	-.001	.032	.004	.044	.000							
8	.044	.103	.042	.253	.106	.113	.075	.000						
9	-.057	-.021	-.005	.015	-.109	-.120	-.072	-.145	.000					
10	.063	-.023	.039	.035	.024	-.070	-.079	-.077	.241	.000				
11	-.032	.015	-.014	-.010	.001	.001	-.058	-.062	.196	.222	.000			
12	-.052	-.060	-.040	-.067	-.051	-.044	.034	-.054	.063	-.070	-.039	.000		
13	.022	-.045	-.010	-.078	.010	-.014	-.029	-.042	-.027	.025	-.051	.070	.000	
14	-.050	-.014	.033	-.034	.004	.054	.036	.020	.090	-.116	-.037	.034	.034	.000

TABLE 26

MODEL 2 FACTOR ANALYSIS

Factor Pattern Matrix

Variable Number	Variable Name	Factor 1 Logical Reasoning	Factor 2 Spanish Read. Comp.	Factor 3 English Read. Comp.
1.	Spanish Nonsense Syllogisms	.180	.016	0.0
2.	Spanish Diagramming Relationships	.483	.339	0.0
3.	Spanish Inference Test	.344	.421	0.0
4.	Spanish Logical Reasoning	.602	.230	0.0
5.	English Nonsense Syllogisms	.270	0.0	.044
6.	English Diagramming Relationships	.357	0.0	.372
7.	English Inference Test	.261	0.0	.557
8.	English Logical Reasoning	.860	0.0	.067
9.	Spanish Vocabulary	0.0	.891	0.0
10.	Spanish Speed	0.0	.828	0.0
11.	Spanish Level	0.0	.846	0.0
12.	English Vocabulary	0.0	0.0	.910
13.	English Speed	0.0	0.0	.884
14.	English Level	0.0	0.0	.861

		1	2	3
Correlations Among Factors	1	1.000		
	2	.471	1.000	
	3	.656	.779	1.000

	1	2	3	4	5	6	7
Uniquenesses:	.965	.498	.568	.453	.909	.559	.431
	8	9	10	11	12	13	14
	.182	.206	.315	.284	.172	.218	.259

Fit of Model: X^2, 66 df = 181.875, p = 0.00

Model 2 all logical reasoning test scores in Spanish or English were allowed to load on Factor 1, but no scores representing performance on reading comprehension in Spanish or English were allowed to load on this factor.

Factor 2 of Model 2 represented reading comprehension in Spanish and was allowed to load on logical reasoning tests in Spanish and on measures of Spanish reading comprehension. The rationale in allowing logical reasoning measures in Spanish to load on the Spanish comprehension factor, as well as on the logical reasoning factor was that scores on Spanish logical reasoning tests were simultaneously a function of applying appropriate rules for deductive reasoning and also a function of appropriately comprehending the linguistic statement of reasoning problems--the latter implying that Spanish reasoning scores hence should also load on a Spanish Comprehension factor.

Factor 3 of Model 2 represented English reading comprehension ability as given by the three measures on the generalized English reading comprehension test and by the four English logical reasoning tests. English logical reasoning tests on Factor 2 were expected to load on Factor 3 to the extent that performance on these tests represented the need to understand the English language statement of logical reasoning problems.

Table 26 gives the results of the factor analysis for Model 2. Each column of the Factor Pattern Matrix pertains to a single hypothesized factor, and the entries in each column give the loading, or linear contribution of each designated measure to that factor. Entires shown as 0.0 are prespecified by hypothesis to assume that value, while other

TABLE 27

RESIDUAL CORRELATIONS FOR FACTOR MODEL 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.000													
2	.125	.000												
3	-.047	.061	.000											
4	.026	-.034	-.032	.000										
5	.120	.035	-.069	-.055	.000									
6	-.013	.095	-.049	-.047	.065	.000								
7	-.019	.008	.042	-.022	-.015	.018	.000							
8	-.029	-.021	-.001	.026	.004	-.007	-.004	.000						
9	-.042	-.023	-.030	.011	-.040	-.057	-.022	-.041	.000					
10	.076	-.033	.008	.024	.058	-.018	-.041	.011	.005	.000				
11	-.013	.037	-.014	.007	.047	.083	.015	.060	-.011	.021	.000			
12	-.048	.001	.037	-.057	-.037	-.043	.013	-.029	.076	-.067	.004	.000		
13	.028	.022	.072	-.062	.026	-.006	-.042	-.011	-.007	.035	-.002	.010	.000	
14	-.043	.060	.122	-.009	.023	.070	.034	.060	-.059	-.097	.022	-.012	-.002	.000

entries are estimated in the factor analysis procedure. One other feature of Model 2 is that it assumed that all three factors were intercorrelated; the estimated correlations among factors are also given in Table 26.

Turning to an interpretation of the pattern of loadings estimated for Factor 1: Logical Reasoning, the measures loading most highly on the underlying reasoning factor were scores on the Spanish Logical Reasoning and English Logical Reasoning tests followed by scores on the Spanish Diagramming Relationships, English Diagramming Relationships and Spanish Inference Test instruments. While three measures, Spanish Nonsense Syllogisms, English Nonsense Syllogisms and English Inference Test had light loadings on the factor, the loadings estimated indicated an expected positive relationship to the underlying logical reasoning factor. The finding that the Spanish Nonsense Syllogisms and English Nonsense Syllogisms did not load highly on the underlying reasoning factor (and also on underlying language comprehension factors) was not surprising given their low internal measurement consistency as represented by their estimated coefficient α reliabilities.

The pattern of loadings of Factor 2--Comprehension in Spanish--for Model 2 revealed high loadings as expected on all measures drawn from the generalized Spanish reading comprehension test. The magnitude of loadings of the various measures of logical reasoning in Spanish on this factor can be interpreted as indicating the extent to which each underlying reasoning test in Spanish depends on Spanish reading comprheension skill.

Similar to Factor 2, Factor 3 of Model 2 corresponding to English reading comprehension showed highest loadings on the underlying measures

of language comprehension hypothesized for it; in this case the highest loadings pertained to the three measures drawn from the generalized English reading comprehension test. Again, similar to the interpretation of Factor 2, Factor 3 loadings on logical reasoning measures in English were taken to represent the degree to which each reasoning test required skills in English reading comprehension.

The intercorrelations among factors reported in Table 26 for Model 2 were substantial, with correlations of .471 between Logical Reasoning and Spanish Comprehension, .656 between Logical Reasoning and English Comprehension, and .779 between Spanish Comprehension and English Comprehension. The higher correlation between the comprehension factors in each language than between each comprehension factor and the Logical Reasoning factor were taken as positive evidence that it was possible to discriminate between logical or deductive cognitive processing on reasoning tests, and reading comprehension processing in either of two languages.

The Chi-square goodness of fit test (66 degrees of freedom) for Model 2 gave a Chi-square value of 181.875 ($p = 0.00$). The customary procedure in confirmatiory maximum likelihood factor analysis is to examine the degree to which a current model improves in fit over a previous model that was theoretically related to the current model. The degree of improvement is taken to be given by change in degrees of freedom of the Chi-square statistic from one model to the next relative to the change in the value of the Chi-square statistic itself. Conceptually this evaluation process in the case of comparison of Model 1 and Model 2 reduces to the notion of how much improvement in fit has been obtained by

postulating three intercorrelated factors representing Logical Reasoning, Spanish Reading Comprehension, and English Reading Comprehension in Model 2 rather than just one general intelligence factor in Model 1. The rationale underlying this evaluation among models is that it is better to accept a simpler conceptual model than a more complex one unless the change in fit among models shows a drastic improvement.

The differences in degrees of freedom between Models 1 and 2 is 77-66=10. According to statistical theory the sum or difference of two independent Chi-square statistics is also a Chi-squared random variable with degrees of freedom equal to the sum or difference of the original Chi-square degrees of freedom. In practice in confirmatory maximum likelihood factor analysis, the difference in obtained Chi-square goodness of fit statistics among contrasted models is often not given a probablistic interpretation in terms of the formal statistical significance of a change between two goodness of fit statistics since such a significant difference is often easily obtainable. Instead the difference in degrees of freedom between the two original statistics is subjectively compared to the drop in the Chi-square statistic in going between a hypothesized better fitting model and an earlier model. Interpretation typically focuses on the magnitude of drop between Chi-square statistics relative to the change in degrees of freedom between two models. This interpretation is thought to be more qualitatively informative than a simple test of significance of the drop between Chi-square statistics.

Between Model 1 and Model 2 the drop in degrees of freedom is 10 while the difference in Chi-square statistics is 243.26. The difference

in magnitude (24 times) between the drop in degrees of freedom and the changes in Chi-Square indicates a that Model 2 dramatically fits the data better than Model 1, though it should be noted that the significance probability itself is still zero that Model 2 fits the data. The failure of the significance probability to achieve a value much different from zero is not usually taken as absolute evidence that a given model does not fit the data since this value tends to zero for large number of subjects regardless of other evidence indicating that a model fits data.

Inspection of the matrix of residual correlations for Model 2 shown in Table 27 revealed that Model 2 was much better at reproducing the original correlation matrix among measures than Model 1. Only two residual correlations out of 91 off-diagonal correlations had non-zero entries in the unit one-tenth space and twenty percent of the residual correlations were now cleared as far as the unit one-hundreth space.

The overall conclusion to be drawn from the Model 2 factor analysis was that positing a single logical reasoning factor and two language of comprehension factors to account for performance of subjects on reasoning and language tests was more appropriate than positing that scores on all tests represented just one common intellectual functioning factor that did not differentiate among reasoning and language skills.

The Model 3 factor analysis hypothesized that it was inappropriate to view performance on logical reasoning in Spanish and English and performance on comprehension tests as manifestations of a single reasoning factor and two other intercorrelating language comprehension factors. According to

Table 28

Model 4 Factor Analysis

Factor Pattern Matrix

Variable Number	Variable Name	Factor 1 Spanish Logical Reasoning	Factor 2 English Logical Reasoning	Factor 3 Spanish Reading Comprehen.	Factor 4 English Reading Comprehen.
1.	Spanish Nonsense Syllogisms	.178	0.0	0.0	0.0
2.	Spanish Diagramming Relationships	.728	0.0	0.0	0.0
3.	Spanish Inference Test	.661	0.0	0.0	0.0
4.	Spanish Logical Reasoning	.698	0.0	0.0	0.0
5.	English Nonsense Syllogisms	0.0	.283	0.0	0.0
6.	English Diagramming Relationships	0.0	.677	0.0	0.0
7.	English Inference Test	0.0	.758	0.0	0.0
8.	English Logical Reasoning	0.0	.795	0.0	0.0
9.	Spanish Vocabulary	0.0	0.0	.891	0.0
10.	Spanish Speed	0.0	0.0	.832	0.0
11.	Spanish Level	0.0	0.0	.847	0.0
12.	English Vocabulary	0.0	0.0	0.0	.907
13.	English Speed	0.0	0.0	0.0	.887
14.	English Level	0.0	0.0	0.0	.861

		1	2	3	4
Correlations Among Factors	1	1.000			
	2	.984	1.000		
	3	.784	.641	1.000	
	4	.838	.872	.773	1.000

	1	2	3	4	5	6	7
Uniquenesses:	.968	.470	.563	.512	.920	.542	.426
	8	9	10	11	12	13	14
	.368	.206	.308	.282	.178	.213	.259

Fit of Model: X^2, 71 df = 214.76, p = 0.00

Model 3; in addition, it would be necessary to split logical reasoning ability on reasoning tests into two distinct but intercorrelated factors pertaining to reasoning from Spanish language materials and reasoning from English language materials, this distinction being in addition to acknowledgment of separate reading comprehension factors in Spanish and English. On conceptual grounds, such a hypothesis would stem from a notion that the underlying thinking processes at work in solving the problems on logical reasoning tests would be substantially and discriminably different as a function of the language of testing. Care should be taken to note that in the current study a strong attempt was made to focus on simple deductive reasoning problems, which one would hope, would not appear different in cognitive task terms from one language to the next.

While Model 3 was meaningful to specify on theoretical grounds it was not possible to estimate an acceptable solution for the model using the COFAMM program. Output from the COFAMM program indicated that the information matrix associated with Model 3 was not positive definite.

An alternative factor model, Model 4 was created to resemble Model 3 closely in terms of the underlying constructs represented but which hopefully, would be more amenable to estimation by the COFAMM program. Model 4 just like Model 3 held that there existed two separate logical reasoning factors in Spanish and English, and two separate language comprehension factors in Spanish and English. The only difference between Model 3 and Model 4 was that each language comprehension factor loaded only on subscores on the language comprehension test in a given language; no provision was made in Model 4 to allow logical reasoning

measures in each language to also load on the comprehension factor in the language of tests. As with Model 3, Model 4 also hypothesized that all the factors extracted were intercorrelated.

The attempt to estimate Model 4 using the COFAMM program was successful and the major results are shown in Table 28. The entries given in the Factor Pattern Matrix all meaningly conform to expectation save for two instances. Each logical reasoning factor in a language displays moderately high to high loadings on each logical reasoning measure in the same language. As was found in the earlier two successful factor analyses, the Spanish Nonsense Syllogisms and English Nonsense Syllogisms did not load well on any factors to which they were hypothesized to contribute towards. The pattern of loadings obtained for reading comprehension subscores on their corresponding language comprehension factors were uniformly very high according to hypothesis.

The Chi-square goodness of fit test for Model 4 with 71 degrees of freedom was 214.761 ($p = 0.00$), an increase of 32.89 over the size of this statistic for Model 2. The difference in degrees of freedom between the Chi-square fit statistics corresponding to Model 2 and Model 4 was 5df, with Model 4 having the higher df. The difference in Chi-square statistics was thus over six times greater than the change in degrees of fredom. Model 2 thus fit the data significantly better ($p < .005$) than Model 4 and supported the conclusion that Model 2--postulating a single reasoning factor in both languages was more appropriate than Model 4 which postulated separate logical reasoning factors in Spanish and English. A comparison of the residual correlations for Model 4 (Table 29) with the residuals for Model 2 (Table 27) does not show an obvious

TABLE 29

RESIDUAL CORRELATIONS FOR FACTOR MODEL 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.000													
2	.121	.000												
3	-.058	.040	.000											
4	.038	-.025	-.032	.000										
5	.127	.032	-.082	-.032	.000									
6	-.016	.056	-.089	-.044	.063	.000								
7	.030	-.044	-.001	-.037	-.028	.000	.000							
8	.002	.000	-.015	.129	.051	.013	-.020	.000						
9	-.076	-.027	028	-.019	-.087	-.035	.041	-.089	.000					
10	.043	-.038	.060	-.005	.041	.001	.016	-.034	.002	.000				
11	-.046	.033	.041	-.022	.031	.104	.075	.014	-.012	.071	.000			
12	-.064	-.023	.039	-.064	-.059	-.026	.076	-.083	-.083	.063	.010	.000		
13	.011	-.005	.071	-.072	.003	.007	.016	-.068	-.005	.034	-.001	.010	.000	
14	-.059	.036	.122	-.018	.002	.085	.092	.006	-.055	-.096	.025	-.009	-.004	.000

pattern of differences which reveal Model 2 as remarkably superior to Model 4.

Differences in Mean Performance on Tests in Spanish and English

This section reports the significance of differences in mean scores on Spanish versus English versions of matched logical reasoning tests. The emphasis of the results reported is on how similar performance was on Spanish and English versions of reasoning tests in relation to gross level of reading comprehension proficiency in both Spanish and English. For this purpose total scores on the Spanish and English reading comprehension tests were dichotomized into categories representing performance above or below the median scoreon each test. The resulting double-dichotomization produced four categories of reading comprehension skills: Low Spanish-Low English; High Spanish-Low English; Low Spanish-High English; and High Spanish-High English. Before exploring the relationship of these categories of reading comprehension skills to performance differences on Spanish versus English versions of logical reasoning tests it will be valuable to first study overall differences on Spanish and English versions of reasoning tests without consideration of level of proficiency in the two languages, and to also compare overall performance on the Spanish and English reading comprehension tests considered alone.

Table 30 summarizes the results of correlated means t-tests conducted on all pairs of logical instruments presented in Spanish and English and on total reading comprehension scores in Spanish and English. The results given indicated that performance on English versions of logical reasoning tests was significantly superior to performance on Spanish

TABLE 30

CORRELATED MEANS T-TESTS FOR ALL PAIRS OF SPANISH AND ENGLISH LOGICAL REASONING TESTS AND FOR TOTAL READING COMPREHENSION SCORES IN SPANISH AND ENGLISH[a]

Test Score Pair	Mean	S.D.	t	df	2 tailed p
Spanish Nonsense Syllogisms	6.92	2.42	-2.11	207	.036
English Nonsense Syllogisms	7.37	2.39			
Spanish Diagramming Relationships	5.45	2.54	-1.85	208	.065
English Diagramming Relationships	5.80	3.12			
Spanish Inference Test	3.80	2.18	-2.55	208	.011
English Inference Test	4.21	2.33			
Spanish Logical Reasoning	7.48	3.89	-5.34	208	.000
English Logical Reasoning	8.73	4.44			
Total Spanish Reading Comprehension	48.47	20.72	-9.04	208	.000
Total English Reading Comprehension	59.45	23.61			

[a]Number of subjects was either 209 or 208 for all analyses.

versions in all except one instance. In this instance performance on the English Diagramming Relationships test was only marginally superior ($p = .065$) to performance on the Spanish Diagramming Relationships test.

In addition Table 30 shows total reading comprehension scores in English were found to be significantly higher than total reading comprehension scores in Spanish. Great care must be exercised in interpreting the meaning of the significant superiority of total English reading comprehension scores over total Spanish reading comprehension scores. Previous work done by Guidance Testing Associates (1967) established preliminary tables for computing equivalent scores on the Spanish and English reading comprehension tests used in the current study. This work showed that a total scores on the English comprehension tests used here were roughly equivalent to the same scores on the Spanish comprehension test used here. The Guidance Testing Associate (1967) report does not give detailed information on the characteristics of the population of subjects used to develop the equivalence tables for Spanish and English reading comprehension tests and hence there is no way of establishing a correspondence between the Spanish and English reading comprehension scores obtained in the current study and the Guidance Testing Associates (1967) tables for comparing performance on reading comprehension tests in the two languages. Manuel (1963), who originally developed the tests used in the current study, did report that the Hispanic population used in developing the tests in question consisted of Puerto Rican and other Hispanic high school and college students during the 1950's and 1960's, however Manuel's (1963) information

is not detailed enough to compare his subjects' characteristics to the subjects of the current study. It is also quite possible that the suitability of items on the reading tests themselves may have changed differentially according to the language of testing as a result of historical alterations in the Spanish and English vocabulary used on test items, and this possibility might be reflected in differences on total scores on both comprehension tests.

On the other hand, despite potential uncontrolled sources of influence which might have resulted in higher scores on the English reading comprehension test than on the Spanish reading comprehension test, there is a real possibility that indeed, overall, subjects are in fact more skillful in reading English than reading Spanish in the language vernacular of comprehension tests as revealed by comprehension test scores. Evidence supporting this latter hypothesis is given by the fact that 47.8 percent of all subjects in the current study judged that English was their best language of reading, in contrast to 24.9 percent who indicated they were better at reading Spanish, and 26.3 percent who judged that they could read equally well in Spanish and English.

Table 31 presents the results of correlated mean t-tests on scores from Spanish and English versions of the same reasoning tests for subjects classified as simultaneously low in both Spanish and English reading comprehension. The results showed that subjects obtained significantly higher scores ($p < .02$) on the English Logical Reasoning test than on the Spanish Logical Reasoning test; differences among mean scores on all other logical reasoning test pairs were found to not be significant for

TABLE 31

CORRELATED MEANS T-TESTS FOR ALL PAIRS OF SPANISH AND ENGLISH LOGICAL REASONING TESTS FOR SUBJECTS CLASSIFIED AS LOW IN BOTH SPANISH AND ENGLISH READING COMPREHENSION[a]

Test Score Pair	Mean	S.D.	t	df	2 tailed p
Spanish Nonsense Syllogisms	7.04	2.58	- .30	78	.767
English Nonsense Syllogisms	7.14	2.26			
Spanish Diagramming Relationships	4.20	2.01	-1.49	79	.139
English Diagramming Relationships	4.63	2.26			
Spanish Inference Test	2.68	1.58	-1.07	79	.289
English Inference Test	2.93	1.51			
Spanish Logical Reasoning	5.53	3.10	-3.73	79	.000
English Logical Reasoning	6.91	3.60			

[a]Number of subjects was either 79 or 80 for all analyses.

the subjects classified as low in both Spanish and English reading comprehension proficiency.

Table 32 gives results of correlated means t-tests on Spanish and English logical reasoning tests for those classified as low in Spanish reading comprhension and high in English reading comprehension. In contrast to the sparsity of significant differences among means on Spanish and English reasoning tests for those judged low in both Spanish and English reading comprehension, performance on English versions of reasoning tests was significantly higher than on Spanish versions of the same reasoning tests in three of four cases for those subjects judged low in Spanish reading comprhension proficiency and high in English reading comprehension. The sole exception to this pattern of significant differences was with the Diagramming Relationships test where the mean score on the English version of the test was only marginally significantly ($p = .079$) greater than the mean score on the Spanish version of the same test.

Table 33 displays the results of correlated means t-tests on Spanish and English version reasoning tests for those subjects classified as high in Spanish reading comprehension and low in English reading comprehension. No major significant differences were found, though the sign of differences among means favored the Spanish version tests over the English verion tests in three of four cases. Scores on the Spanish Logical Reasoning test were greater than scores on the English Logical Reasoning test at a marginally significant level ($p = .076$).

The results of the final set of correlated means t-tests on Spanish and English versions of reasoning tests involved those subjects classified

TABLE 32

CORRELATED MEANS T-TESTS FOR ALL PAIRS OF SPANISH AND ENGLISH LOGICAL REASONING TESTS FOR SUBJECTS CLASSIFIED AS LOW IN SPANISH READING COMPREHENSION AND HIGH IN ENGLISH READING COMPREHENSION[a]

Test Score Pair	Mean	S.D.	t	df	2 tailed p
Spanish Nonsense Syllogisms	6.00	1.98	-2.78	23	.011
English Nonsense Syllogisms	7.97	2.04			
Spanish Diagramming Relationships	5.58	1.44	-1.40	23	.174
English Diagramming Relationships	6.46	2.55			
Spanish Inference Test	3.67	1.55	-3.29	23	.003
English Inference Test	5.33	2.04			
Spanish Logical Reasoning	7.46	2.67	-3.88	23	.001
English Logical Reasoning	9.42	2.69			

[a]Number of subjects was 24.

TABLE 33

CORRELATED MEANS T-TESTS FOR ALL PAIRS OF SPANISH AND ENGLISH LOGICAL REASONING TESTS FOR SUBJECTS CLASSIFIED AS HIGH IN SPANISH READING COMPREHENSION AND LOW IN ENGLISH READING COMPREHENSION[a]

Test Score Pair	Mean	S.D.	t	df	2 tailed p
Spanish Nonsense Syllogisms	6.12	2.57	-1.38	25	.179
English Nonsense Syllogisms	6.92	2.56			
Spanish Diagramming Relationships	4.15	2.17	.60	25	.555
English Diagramming Relationships	3.92	2.38			
Spanish Inference Test	2.81	1.60	.53	25	.600
English Inference Test	2.58	1.65			
Spanish Logical Reasoning	6.35	2.80	1.85	25	.076
English Logical Reasoning	5.38	2.84			

[a]Number of subjects was 26.

simultaneously as high in both Spanish and English reading comprehension. The outcome of these analyses given in Table 34 revealed that performance on English version reasoning tests was higher than on Spanish version reasoning tests, but that these differences were significant only in the case of the Logical Reasoning test.

TABLE 34

CORRELATED MEANS T-TESTS FOR ALL PAIRS OF SPANISH AND ENGLISH LOGICAL REASONING TESTS FOR SUBJECTS CLASSIFIED AS HIGH IN SPANISH READING COMPREHENSION AND HIGH IN ENGLISH READING COMPREHENSION[a]

Test Score Pair	Mean	S.D.	t	df	2 tailed p
Spanish Nonsense Syllogisms	7.34	2.21	- .80	78	.425
English Nonsense Syllogisms	7.62	2.55			
Spanish Diagramming Relationships	7.10	2.48	- .91	78	.367
English Diagramming Relationships	7.42	3.42			
Spanish Inference Test	5.32	2.15	-1.46	78	.148
English Inference Test	5.70	2.21			
Spanish Logical Reasoning	9.84	4.01	-3.96	78	.000
English Logical Reasoning	11.47	4.45			

[a]Number of subjects was 79.

CHAPTER IV

SUMMARY AND DISCUSSION

The present study addressed three major research questions regarding abilities of 209 bilingual Puerto Rican college students to solve problems presented on four pairs of logical reasoning tests written in Spanish and English. The three major research questions were:

Area 1 To what extent is the ability to solve logical reasoning problems in either Spanish or English related to reading comprehension skill in the lanugage of problems? On an exploratory basis is there any evidence that Puerto Rican subjects' language, educational and socioeconomic background extenuates this relationship?

Area 2 What evidence exists that Puerto Rican subjects' ability to solve logical reasoning problems represents a unique trait distinct from reading comprehension ability in Spanish or English?

Area 3 Are there significant differences in Puerto Rican subjects' performance on Spanish versus English language logical reasoning tests? Are such differences related to reading comprehension proficiency in Spanish and English?

Discussion of Area 1 of Research

The data analyses addressing the first question of research showed that performance on logical reasoning tests in either Spanish or English

was strongly related to reading comprehension skill in the language of reasoning problems. Among immediate measures of reading comprehension during administration of reasoning tests, average reading time for the first reading of logical reasoning problems, preceding an attempt to solve problems was found to be a significant predictor of logical reasoning test performance in either language on virtually every single logical reasoning instrument. In further analyses recently completed this finding was robust in that even after introducing number of items worked on each Spanish and English reasoning test as an independent variable in regression analyses, average reading time for items still remained a significant contributor to prediction of overall performance on reasoning tests. Previous research on bilingualism and cognition has shown that reading and mental processing speed in a weaker second language impedes performance of tasks in a second language over the level of performance obtainable in a first language (see e.g., Macnamara and Kellaghen, 1968; Kolers, 1966; Lambert et al., 1959 and d'Anglejan and Tucker, 1975). Most of this previous work involved bilinguals whose first language was the dominant language. The bilingual population of the current study is heterogeneous in that regard, with perhaps more persons actually being dominant in reading English--their second language--than Spanish. The results of the current project show that for this heterogeneous population of Puerto Rican bilinguals in U. S. four year colleges, that reading speed during performance of cognitive tasks stated in either Spanish or English is a significant predictor of success in solving reasoning problem tasks.

In contrast to average reading speed for logical reasoning items, other measures of reading comprehension during solution of logical reasoning problems such as number of times used other language; number of words not understood; and number of sentences not understood tended not to be significant contributors to prediction of logical reasoning performance. The lack of predictive efficacy of these latter measures may arise from the inability of subjects to accurately report the requested information, but taken at face value the failure of these measures to consistently and substantially predict logical reasoning problem performance in either language is somewhat comensurate with the finding of Macnamara and Kellaghen (1968) that bilinguals may show evidence of comprehending each sentence in a verbal problem in a weaker second language and yet not be as successful at solving such a problem in a second language as in a first language. Further work is needed on analyzing data in the current project to test this hypothesis of Macnamara and Kellaghen.

The inclusion of general reading comprehension measures in each language in investigating Area 1 of research was to learn the extent to which performance on logical reasoning tests could be linked to the broader repertoire of comprehension skills bilinguals possess in a language which may mediate cognitive performance of tasks in a manner that in fact may not be easily assessed right during performance of cognitive tasks. The findings of the current research were that inclusion of general measures of vocabulary comprehension, speed of comprehension and level of comprehension in each language contributed very significantly to prediction of performance on logical reasoning tests in each language

beyond the extent of prediction possible by only considering the previously mentioned immediate measures of reading comprehension during logical reasoning problem solution.

The major significance of the results thus far reported was that a high degree of consistency was obtained in the pattern of how well various measures of immediate or general reading comprehension predicted performance across alternative reasoning tests and across languages as well. The results did not show, contrary to expectation, that logical reasoning tests which required more forms of language processing (e.g., sentence comprehension in text) were clearly more dependent on verbal comprehension measures than reasoning tests involving less language processing (e.g., comprehension of isolated words). Across languages, the extent to which logical reasoning performance was predicted by combined immediate and generalized reading comprehension measures was quite interpretable. The finding was that immediate and generalized reading comprehension measures in English were somewhat better predictors of performance on logical reasoning tests in English, than were similar measures in Spanish for predicting performance on logical reasoning tests in Spanish. The pattern of prediction across languages and reasoning tests however was quite similar in that regardless of language or test--except for the Nonsense Syllogisms test--about two to three times more variance in performance on reasoning tests was gained by adding in the influence of generalized reading comprehension measures to the predictive influence of immediate reading comprehension measures obtained during reasoning test administration. The results overall suggest that

there is a very similar involvement of reading comprehension skills in Spanish and English with success in solving deductive reasoning processes stated in those languages for the Puerto Rican college students studied.

The final phase of activities in the first area of research explored how various background variables concerning Puerto Rican subjects' might extenuate the findings thus far reported. Preliminary data showed that there were significant correlations between prestige of father's occupation, prestige of mother's occupation, and prestige of student's expected occupation and logical reasoning test scores administered in both languages. Scores on logical reasoning tests in English were found to be significantly correlated with several variables relating to years schooled or lived on Puerto Rico versus the U. S. Mainland. No similar relationships were found for Spanish language reasoning tests apart from for the Spanish Logical Reasoning test. Subsequent regression analyses which introduced these background variables (with the exception of mother's occupation) as predictors of logical reasoning test scores in addition to measures of reading comprehension in the language of tests led to the clear conclusion that newly introduced background variables added essentially nothing to prediction of logical reasoning test scores in either language.

Preliminary data on place of schooling (Puerto Rico vs U. S. Mainland vs Both), language of schooling (Spanish and English vs English only), and judgment of best reading language showed that such factors were not overwhelmingly and significantly related to performance on Spanish logical reasoning tests, but were overwhelmingly and significantly

related to performance on logical reasoning tests in English. In later analyses attention was focused on the influence high school language and judgment of best reading language might have on reasoning test scores in either language after statistically controlling for the effects of reading comprehension skills in Spanish and English on reasoning test scores in either language.

For Spanish language logical reasoning tests these later analyses showed that there was a small but significant benefit to performance due to exposure to English in high school and judgment of English as the best language of reading. This small positive effect existed independent of the strong positive effect that skill in Spanish reading comprehension had on performance on Spanish logical reasoning tests. No complementary effect of this sort was found for performance on logical reasoning tests in English in relation to exposure to Spanish in high school or judgment that Spanish was the best reading language.

The overall conclusion to be drawn from an exploratory research on how background variables extenuate the relationship between reasoning test performance and language comprehension skills is that there is evidence supporting the hypothesis that greater exposure to English and preference for reading English may be allied somehow with a slight facilitation in solving artificial logical problems on the sort used in the current project. The locus of this facilitation may lie either in background differences among subjects or in the way Spanish version instruments were adapted from their English language counterparts. Further research on these issues will require first investigating which

items on Spanish and English version tests are most allied with the facilitation of performance that has been mentioned.

The overwhelming conclusion which emerges from the exploratory background research is that language comprehension skills in themselves, by and large, capture the major influences such variables might have on performance on reasoning tests in either Spanish or English. Again, care must be taken to note that further research on background influences is needed in the current project and that the results obtained here may not generalize to broader components of the Puerto Rican student population or to other kinds of reasoning problems stated in Spanish and English.

Discussion of Area 2 of Research

Previous research on mental abilities of bilinguals shows very little evidence of attempts to verify whether particular cognitive abilities, such as deductive reasoning skills can be convergently assessed by reasoning test materials in two languages. In this regard, the present research attempted to study whether Puerto Rican subjects' ability to solve logical reasoning problems of specific sorts was highly intercorrelated across Spanish and English tests and whether logical reasoning skills could be discriminated from reading comprehension ability in either Spanish or English. The method used to explore this issue was confirmatory maximum likelihood factor analyses. A significant conceptual advantage to the factor analysis approach was that it was not influenced by the existence of a real difference in the mean scores of the measures analyzed. Thus in the current work the analyses and the conclusions drawn were not affected by the fact that subjects were found

overall, to perform significantly better on tests in English than on tests in Spanish.

The results of factor analyses clearly showed that Puerto Rican subjects' performance on logical reasoning tests and reading comprehension tests in each language did not conform to a single underlying cognitive ability construct. Evidence from factor analyses indicated that a single logical reasoning factor--without regard to language--and separate reading comprehension factors in each language was more adequate in accounting for the intercorrelation among scores on all logical reasoning and reading comprehension tests than a single factor model. An attempt was made to test the plausibility of a factor model which distinguished between skill in solving logical reasoning problems in Spanish and skill in solving logical reasoning problems in English, in addition to separate skills in Spanish versus English comprehension. The results while not definitive, indicated that postulating a single logical reasoning factor regardless of language of reasoning problems was statistically more reasonable than postulating separate reasoning factors in each language.

Caution needs to be exercised in interpreting the generality of the evidence that a single logical reasoning factor underlies performance of Puerto Rican students on tests used in the current study. First of all the result may generalize only to other Puerto Ricans with similar background profiles who are enrolled primarily in four year U. S. mainland colleges with a similar range of reading proficiency skills in Spanish and English. The results obtained may not hold for Puerto Ricans who

have been schooled entirely in Puerto Rico and who are attending four year colleges in Puerto Rico. These latter students may have been exposed, by and large, to different educational and testing experiences in Puerto Rico than the majority of students participating in the current project who have gone to school mostly on the U. S. mainland. Further research on this question would need to involve students attending college in Puerto Rico.

A second needed caution is that since the current study has not directly investigated the variety and types processes subjects follow in solving problems, there is no direct evidence that subjects are doing the same cognitive acts in working logical reasoning test items presented in separate languages. This issue is left as a question for further research.

A third needed caution is that it is very likely to be the case that problem solving in two languages will reflect cultural and linguistic influences more dramatically when less artificial and more linguistically complex tasks are examined. Indeed a considerable research literature (see Oakland 1977 for a recent example) exists that cites the wide range of biases that are inherent in studying cognitive aptitudes and achievement among persons from multicultural and multilingual backgrounds. As part of this issue it must be recognized that the term "logical reasoning" as applied to the kinds of problems used in the current study is not definitive in any sense and that in reality many forms of thought very different from what is required to work problems in the current study could also be termed "logical reasoning." Some of these alternative forms of logical reasoning (e.g., rules for numerical computation in verbal arithmetic problem solving) may very well show strong cultural and linguistic

influences among bilinguals familiar with Spanish and English in a way that would not lead to a conclusion that the same underlying skills are involved in the solution of problems that appear to be superficially similar in structure and meaning across languages. This question area would seem a valuable one for future research.

Discussion of Area 3 of Research

The third area of research in the current project investigated differences in level of performance on logical reasoning tests administered in Spanish and English as a function of pattern of reading comprehension proficiency in Spanish and English. Overall, Puerto Rican bilingual subjects were found to perform significantly higher on all English version logical reasoning tests than on Spanish versions. In addition, overall, subjects scored significantly higher on English reading comprehension than on Spanish reading comprehension. The emphasis of analyses was on how the differences between Spanish and English version logical reasoning tests changed as a function of high versus low reading proficiency in both Spanish and English. Four proficiency groupings were created: low Spanish-low English; high Spanish-low English; low Spanish-high English; and high Spanish-high English and used for purposes of analyses.

The findings were that Puerto Rican subjects who were judged to be roughly equivalent in reading comprehension proficiency in Spanish and English tended not to differ very much on their level of performance on matched Spanish versus English version logical reasoning tests (with one exception), though the trend of what ever differences existed favored higher performance on English version tests. Subjects who were classified

as high in English reading comprehension proficiency and low in Spanish reading comprehension proficiency performed significantly better on English version tests (with one exception) as expected. However, a comparable significant advantage on Spanish version reasoning tests was not found for subjects who were classified as high in Spanish reading proficiency and low in English reading proficiency, though the differences that existed among test score means uniformly showed higher performance on Spanish version reasoning tests.

The pattern of results which have been reported partially do support the conclusion that Puerto Rican subjects were better at solving logical reasoning problems written in the language they read best. The results, however, also suggest subjects were better overall at solving logical reasoning problems in English than in Spanish. Several factors could underlie this latter finding.

First of all it may be the case that the majority of subjects classified as equivalent in Spanish and English reading comprehension, in fact are better at reading English than Spanish, and this discrepancy may lead to better performance on reasoning tests in English. An extension of the current project could investigate this hypothesis without further data collection.

A second factor that may be responsible for effects of superior performance on English logical reasoning tests over Spanish version tests may be that Puerto Rican subjects, regardless of reading comprehension skills in Spanish and English, may have more aptitude and achievement test taking experience in English than in Spanish, and this may lead directly to an advantage on English logical reasoning tests. Investigation of this issue would require a new research project with this focus.

A third factor that may be operating concerns the suitability of Spanish translations of the original English version logical reasoning tests. While the level of English used in stating reasoning problems on all tests was relatively simple and relatively free of idiomatic constructions, it could be the case that the modified, literal translation scheme which was followed in the present project led to Spanish version items which varied in their intelligibility to Puerto Ricans with different Spanish literacy backgrounds. Puerto Rican subjects schooled largely in the United States in English at times may have found Spanish version items more intelligible than subjects with more schooling in Spanish, since it is quite possible the former subjects are compound bilinguals whose knowledge of Spanish literacy forms could be strongly mediated through their knowledge of English. The net result of such an influence would be that subjects who were more proficient in Spanish reading comprehension on occasion may have found Spanish reasoning problems a little awkward to comprehend and this may have slightly attenuated their performance on tests in Spanish. Research on this issue could be conducted in a new study having highly fluent Spanish, bilinguals rate the intelligibility of materials used in the current project. On another tact new research addressing advantage of performance in one language over the other similar to the current project could begin with specially developed Spanish language reasoning tests which would be composed at the outset by persons with high fluency in Spanish and familiarity with Puerto Rican experiences on both U. S. and Puerto Rico. Research could then proceed to investigate whether literal English translations of Spanish materials would lead to a deficit on performance on English version tests.

Contemporary Cognitive Research and the Current Project

Among other results the current project has led to tentative evidence that bilinguals' skill in solving deductive reasoning problems on tests in Spanish and English is both related and distinguishable from their reading comprehension skills in Spanish and English. Such evidence is consistent with many contemporary information processing accounts of cognition (see e.g., contributions in Bobrow and Collins, 1975; Norman and Rumelhart, 1975; Anderson, 1976; and Lachman et al., 1979) which postulate that most human problem solving involves the manipulation of information representing problem elements in a mental code which is different form natural language. Hypothetically, from the perspective of such accounts of cognition, bilinguals' solution of logical reasoning problems of the sort used in the present study might involve transformation of the linguistic statement of problems from either Spanish or English into a single kind of mental code which is consistent with the cognitive format of a decision procedure individuals use for solving deductive reasoning problems. Subsequent to comprehension of the linguistic statement of reasoning problems, success in solving a problem becomes a function of the suitability of the decision procedure employed to reach a problem solution. Decision procedures for working deductive reasoning problems would likely rely on knowledge stored in long term memory for how to go about solving different classes of related problems, such as syllogisms, category relationships, etc.

The hypothesis that internal knowledge and decision procedures for solving problems is separable from the linguistic statement of problems

finds a natural arena for research in the area of the current project in that new work could be initiated to investigate more carefully the extent to which bilinguals are capable of solving similar underlying logical reasoning problems stated in two languages. The purpose of new work would be to link research on bilingualism to current research on cognition in order to derive improved knowledge of thinking process in bilinguals. Such research might proceed by carefully matching the problems presented to bilinguals in each of two languages. Matching might be based on a number of criteria such as syntactic and semantic equivalency of problem statement, equivalence only of logical structure and syntactic structure of problems, or similarity of logical structure only. Many criteria for matching problems are possible and just a few have been mentioned. Subsequent data analyses could then investigate the relative success of bilinguals in solving different kinds of matched reasoning problems in two languages. The efforts of the current project have shown that skill in reading comprehension in two languages will be an important factor in limiting success in solving problems in either of two languages and that this fact will be in need of consideration in further research. The ultimate outcome fo such work would be more refined knowledge on how bilinguals are able to transfer problem solving knowledge across different domains of language form and structure used to state related reasoning problems in two languages.

Educational Significance of the Project

In order to improve educational equity and opportunities for Puerto Ricans in U. S. colleges great sensitivity is needed on the part of

school personnel and academic test designers on how to optimally assess cognitive and achievement skills among Puerto Ricans. The results of the present study have shown that assessment of cognitive skills in bilingual Puerto Rican college students in either Spanish or English can lead to convergently valid information about particular thinking skills in relation to reading comprehension skills in either language. The results also show that reading comprehension skills in Spanish and English capture most, but not all, of the influence that a few background variables related to socioeconomic status, language of schooling and location of schooling have on reasoning test scores in either language, though caution needs to be exercised in interpreting this finding in that the work was truly exploratory and did not involve an extensive consideration of many different forms of background data. Also, the current work found difficulty in probing the exposure of Puerto Rican students to Spanish and English during schooling on Puerto Rico thus indicating the need for further work on how language of schooling is related to performance in problem solving in Spanish and English.

The present work has also established the possibility that use of literal translation of test materials from English to Spanish--even in the case of relatively simple materials--may subtley favor performance on English reasoning problems over performance on Spanish reasoning problems in a manner that is not captured by gross measures of reading comprehension proficiency in two languages. The root causes of this facilitation of performance on English reasoning tests among U. S. Mainland Puerto Rican college students is in need of further research.

The major educational implication of the present work is that testing and aptitude assessment of Puerto Rican college student applicants needs to be sensitive to the broader range of background and language characteristics of students which influence their cognitive aptitudes and achievement in schooling. The present study has focused primarily on Puerto Rican students enrolled in four year colleges and these students represent a select but growing component of the general adult Puerto Rican population who acquiring access to schooling beyond high school. It is important that the results of a research study such as the current one not be assumed automatically to be valid for Puerto Rican students largely enrolled in non four year colleges or in other institutions of higher learning or vocational training beyond high school. Research on the cognitive aptitudes and educational achievement at any educational site needs to be designed, conducted and interpreted based on an awareness of the language and background characteristics of Puerto Rican students who are the particular individuals who are studied.

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APPENDIX

Núm. de Identificación_____

PRUEBA DE SILOGISMOS ABSURDOS--RL-1, Forma S2

Esta es una prueba de su habilidad de poder decidir si la conclusión derivada de ciertas declaraciones llamadas silogismos es correcta o incorrecta. Aunque todas las declaraciones son realmente absurdas, usted asumirá que las primeras dos declaraciones en cada problema son correctas. La conclusión derivada de ellas puede pero no tiene que necesariamente representar un buen razonamiento.

Analise las declaraciones tomando en consideración cada uno de los siguientes puntos:

a) Apunte la hora cuando primero empezó a leer el silologismo en el espacio marcado "Empezó a leer". Apunte también la hora cuando terminó de leer el silologismo por primera vez en el espacio marcado "Terminó de leer".

b) Si la conclusión derivada del silologismo muestra buen razonamiento, ponga una X sobre la letra B. Si la conclusión derivada del silologismo muestra un razonamiento malo, ponga una X sobre la letra M.

c) Luego, repase y subraye la(s) palabra(s) en el silologismo cuyo(s) significado(s) no entendió bien.

d) En el espacio en que se pregunta, "¿Usó inglés?", marque "Sí" si usted mentalmente tradujo un silologismo, o parte de él, al inglés o si usted pensó en inglés al seleccionar la respuesta.

Ahora ponga a prueba estos problemas de muestra:

1. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Todos los árboles son peces. Todos los peces son caballos. Por lo tanto, todos los árboles son caballos.

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

Respuesta: B M

¿Usó inglés? Sí_____ No_____

2. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Todos los árboles son peces. Todos los peces son caballos. Por lo tanto, todos los caballos son arboles.

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

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Respuesta: B M

¿Usó ingles? Sí_____ No_____

3. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Algunas piscinas son mantañas. A todas las montañas les gustan los gatos. Por lo tanto, a todas las piscinas les gustan los gatos.

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

Respusta: B M

¿Usó inglés? Sí_____ No_____

4. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Todos los elefantes pueden volar. Todos los gigantes son elefantes. Por lo tanto, los gigantes pueden valar.

Termin de leer: Hora:_____ Min:_____ Segundos:_____

Respuesta: B M

¿Usó inglés? Sí_____ No_____

5. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Algunas zanahorias son carros deportivos.
Algunos carros deportivos tocan el piano.
Por lo tanto, algunas zanahorias tocan el piano.

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

Respuesta: B M

¿Usó inglés? Sí_____ No_____

Las respuestas a los ultimos cinco problemas son las siguientes:
1 es B; 2 es M; 3 es B; 4 es B; 5 es M.

Su puntaje en esta prueba estará compuesto del número de respuestas marcados correctamente menos 1 número marcado incorrectamente. Por lo tanto, no será ventajoso para usted adivinar la respuesta a menos que tenga alguna idea acerca de si el razonamiento es bueno o malo.

Tendrá 6 minutos para terminar esta prueba.

NO PASE A LA SIGUIENTE PÁGINA HASTA QUE SE LE PIDA HACERLO

Identification No. _____

NONSENSE SYLLOGISMS TEST -- RL-1, FORM E1

This is a test of your ability to tell whether the conclusion drawn from certain statements called syllogisms is correct or incorrect. Although all of the statements are really nonsense, you are to assume that the first two statements in each problem are correct. The conclusion drawn from them may or may not show good reasoning. You are to think only about the reasoning.

In working each item:

a) Note down the time when you first start to read a syllogism in the space provided above the syllogism, and the time when you end your first reading of the syllogism in the space provided below the syllogism.

b) If the conclusion drawn from a syllogism shows good reasoning, put an X on the letter G. If the conclusion drawn from the syllogisms shows poor reasoning, put an X on the letter P.

c) Next, go back and underline any words in the syllogism whose meaning you were not sure of.

d) In the space stating "Use Spanish?", check "Yes" if you mentally translated a syllogism or part of it into Spanish, or if you thought in Spanish in picking the correct answer. Check "No" otherwise.

Now try the practice problems given below.

1. Start Read: Hr: _____ Min: _____ Secs: _____

All trees are fish. All fish are horses. Therefore, all trees are horses.

End Read: Hr: _____ Min: _____ Secs: _____

Answer: G P

Use Spanish? Yes _____ No _____

2. Start Read: Hr: _____ Min: _____ Secs: _____

All trees are fish. All fish are horses. Therefore, all horses are trees.

End Read: Hr: _____ Min: _____ Secs: _____

Answer: G P

Use Spanish? Yes _____ No _____

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3. Start Read: Hr: _____ Min: _____ Secs: _____

Some swimming pools are mountains. All mountains like cats. Therefore, all swimming pools like cats.

End Read: Hr: _____ Min: _____ Secs: _____

Answer: G P

Use Spanish? Yes _____ No _____

4. Start Read: Hr: _____ Min: _____ Secs: _____

All elephants can fly. All giants are elephants. Therefore, all giants can fly.

End Read: Hr: _____ Min: _____ Secs: _____

Answer: G P

Use Spanish? Yes _____ No _____

5. Start Read: Hr: _____ Min: _____ Secs: _____

Some carrots are sports cars. Some sport cars play the piano. Therefore, some carrots play the piano.

End Read: Hr: _____ Min: _____ Secs: _____

Answer: G P

Use Spanish? Yes _____ No _____

The answers to the five problems are as follows: 1 is G; 2 is P; 3 is G; 4 is G; 5 is P.

Your score on this test will be the number marked correctly minus the number marked incorrectly. Therefore, it will <u>not</u> be to your advantage to guess unless you have some idea whether the reasoning is good or bad.

You will have <u>6 minutes</u> for this test.

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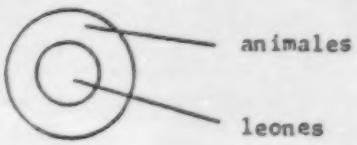
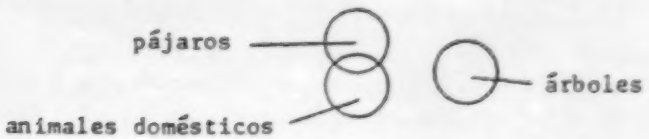
RELACIONES GRÁFICAS--RL-2, Forma S 2

Algunas veces las relaciones entre grupos de cosas pueden ser explicadas mejor por esquemas que consisten de círculos que se cubren en parte. Por ejemplo, si ciertas cosas específicas, digamos leones, pertenecen a una clase más grande de cosas, digamos animales, usted podría representar la situación de la siguiente forma:



En estos esquemas no nos importan los tamaños relativos de ninguno de los círculos. Es decir, no estamos sugiriendo aquí que una proporción relativamente grande de animales son leones, sino que estamos indicando que <u>todos</u> los leones son animales dentro del círculo que representa a los animales.

Ahora tomemos las relaciones entre tres grupos de cosas diferentes: pájaros, animales domésticos, y árboles. Estos deben de ser representados de la siguiente forma:



Este esquema muestra que <u>ningún</u> árbol es un pájaro o un animal doméstico, pero que <u>algunos</u> pájaros son animales domésticos y <u>algunos</u> animales domésticos son pájaros.

Cada problema en esta prueba nombra tres grupos de cosas. Usted tiene que escoger de los esquemas que se encuentran en la parte superior de cada página de la prueba, el esquema que representa la relación correcta entre los tres grupos de cosas en cada problema. Marque la letra del esquema que usted escoja.

Analise los problemas tomando en consideración cada uno de los siguientes puntos:

a) Apunte la hora cuando primero empezó a leer las tres palabras de un problema en el espacio marcado "Empezó a leer". Apunte también la hora cuando terminó de leer las palabras por primera vez en el espacio marcado "Terminó de leer".

b) Ponga un círculo sobre la letra que corresponde al esquema que seleccionó.

c) Luego, repase y subraye cualquiera(s) de la(s) tres palabras del problema cuyo(s) significado no entendió.

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d) En el espacio en que se pregunta "¿Usó inglés?" marque "SÍ" si al ... las tres palabras del problema usted mentalmente tradujo al inglés ... si usted pensó en inglés al seleccionar la respuesta.

Ahora ponga a prueba estos problemas de muestra.

1. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Animales, gatos, perros

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

A B C D E

¿Usó inglés? Sí_____ No_____

2. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Escritorios, muebles, lápices

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

A B C D E

¿Usó inglés? Sí_____ No_____

Usted debería haber marcado A para 1 y E para 2.

Su puntaje en esta prueba estará compuesto del número de respuestas correctas menos una fracción del número de respuestas incorrectas, por lo tanto no será ventajoso para usted adivinar, a menos que usted tenga alguna idea que le ayude a hacer una selección correcta.

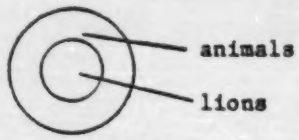
Tendra 6 minutos para terminar esta prueba.

NO PASE A LA SIGUIENTE PÁGINA HASTA QUE SE LE PIDA HACERLO.

Identification No. _____

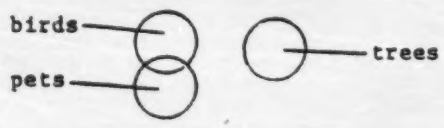
DIAGRAMMING RELATIONSHIPS — RL-2 FORM E1

Sometimes the relationships among groups of things are best explained by diagrams that consist of overlapping circles. For example, if certain specific things, let's say lions, all belong to one larger class of things, let's say animals, you could diagram the situation as follows:



In these diagrams we do not care about the relative sizes of any of the circles. That is, we are not suggesting here that a relatively large proportion of animals are lions, but we are indicating that all lions are animals. That is why the circle representing lions is drawn entirely within the circle that represents animals.

Now take the relationships among three groups of different things: birds, pets, and trees. These should be diagrammed as follows:



This diagram shows that no trees are either pets or birds, but some birds are pets and some pets are birds.

Each item in this test names three groups of things. You are to choose from the lettered diagrams at the top of the test pages the one diagram that shows the correct relationships among the three groups of things in each item. Mark the letter of the diagram that you select.

In working each item:

a) Note down the time when you first begin to read the three words of an item in the space provided above the three words, and the time when you finish your first reading of the three words--in the space provided below the three words.

b) Go on to circle the letter of the diagram that you select.

c) Next, go back and underline any of the three words whose meaning you were not sure of.

d) In the space provided, "Use Spanish?" check "Yes" or "No" if translation or mental use of Spanish occurred in reading the three words or in selecting the appropriate diagram.

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1. Start Read: Hr: _____ Min: _____ Secs: _____

Animals, cats, dogs

End Read: Hr: _____ Min: _____ Secs: _____

A B C D E

Use Spanish? Yes _____ No _____

2. Start Read: Hr: _____ Min: _____ Secs: _____

Desks, furniture, pencils

End Read: Hr: _____ Min: _____ Secs: _____

A B C D E

Use Spanish? Yes _____ No _____

You should have marked A for 1 and E for 2.

Your score on this test will be the number of correct choices minus a fraction of the number of incorrect choices. Therefore, it will <u>not</u> be to your advantage to guess, unless you have at least some idea that will help you make a correct choice.

You will have 6 minutes to work on this test.

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PRUEBA DE INFERENCIA--RL-3, Forma, S2

Cada pregunta de esta prueba incluye una o dos declaraciones similares a la que se encuentran en periodicos o revistas populares. Las declaraciones son siguidas por varias conclusiones que algunas gentes podrán derivar de ellas. En cada caso, decida cual conclusión puede ser derivada de la(s) declaración(s) asumiendo nada adicional a la información provista por la(s) declaración(s).

Analise las preguntas tomando en consideración cada uno de los siguientes puntos.

a) Apunte la hora cuando primer empezó a leer la pregunta en el espacio: "Empezó a leer". Apunte también la hora cuando terminó de leer la pregunta por primera vez en el espacio marcado: "Terminó de leer".

b) Ponga una X enfrente de la respuesta que seleccionó.

c) Luego, repase y subraye la(s) palagra(s) en la pretunta cuyo(s) significado no entendió. Ponga un signo de interrogación despues de la(s) frase(s) que no comprendió bien.

d) En el espacio en que se pregunta "¿Usó ingles?", marque "Sí" si usted mentalmente tradujo una frase, o parte de ella, al inglés o si usted pensó en inglés al seleccionar la respuesta.

Considere la siguiente pregunta de muestra:

1. Empezó a leer: Hora:_____ Min:_____ Segundos:_____

Juan, miembro del equipo de baloncesto, mide 6 pies, 2 pulgadas y pesa 195 libras. Para calificar en el equipo, una persona debe tener, por lo menos, 5 pies 10 pulgadas de altura.

Terminó de leer: Hora:_____ Min:_____ Segundos:_____

Respuesta:

a) Entre mas alto sea un hombre, mejor jugador de baloncesto es.
b) Los jugadores de baloncesto frequentemente son bajos de peso.
c) Algunos jugadores del equipo miden más de 6 pies.
d) Juan es más grande que el hombre promedio.
e) Los mejores jugadores de baloncesto provienen de los rangos de hombres más grandes que el promedio.

¿Uso inglés? Sí_____ No_____

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Sólo la conclusión 3 puede ser derivada sin asumir que usted tiene información o conocimiento adicional al que dan las declaraciones. Las declaraciones no dicen nada acerca de lo bueno que son diferentes jugadores, nada acerca de si ellos son bajos de peso, y nada acerca de los hombres de altura promedio o más altos que el promedio.

Su puntaje en esta prueba será el número marcado correctamente menos alguna fracción del número marcado incorrectamente. Por lo tanto, no será ventajoso para usted adivinar la respuesta a menos que sea capaz de eliminar una o más de las selecciones de las respuestas como incorrectas.

Tendrá 10 minutos para cumplir esta prueba.

NO PASE A LA SIGUIENTE PÁGINA HASTA QUE SE LE PIDA HACERLO

 Identification No. _____

INFERENCE TEST -- RL-3, FORM E1

In each item on this test you will be given one or two statements such as you might see in newspapers or popular magazines. The statements are followed by various conclusions which some people might draw from them. In each case, decide which conclusion can be drawn from the statement(s) without assuming anything in addition to the information given in the statement(s). There is only one correct conclusion.

In working each item:

a) Note down the time when you first start to read statements for an item in the space provided, and the time when you end your first reading in the space provided.

b) Mark your answer by putting an X through the number in front of the conclusion you select.

c) Next, go back and underline any words in the statements for an item whose meaning you were not sure of. If you were not sure of the meaning of entire sentences, put a question mark at the end of the sentence.

d) In the space stating, "Use Spanish?", check "Yes" if you mentally translated an item or parts of it into Spanish, or if you thought in Spanish in picking an answer. Check "No" otherwise.

Consider the following sample item:

1. Start Read: Hr: _____ Min: _____ Secs: _____

Bill, a member of the basketball team, is 6 feet, 2 inches tall and weighs 195 pounds. To qualify for the team, a person must be at least 5 feet, 10 inches tall.

End Read: Hr: _____ Min: _____ Secs: _____

Answer:
a. The larger a man is, the better basketball player he is.
b. Basketball players are often underweight.
c. Some players on the team are more than 6 feet tall.
d. Bill is larger than the average man.
e. The best basketball players come from the ranks of larger-than-average men.

Use Spanish? Yes _____ No _____

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Only conclusion 3 may be drawn without assuming that you have information or knowledge beyond what the statements give. The statements say nothing about how good different players are, nothing about whether they are underweight, and nothing about average or taller-than-average men.

Your score on this test will be the number marked correctly minus some fraction of the number marked incorrectly. Therefore, it will <u>not</u> be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have <u>10 minutes</u> to complete this test.

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